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THE SEARCH FOR OIL

G. M. LEES

Eighth Asia Lecture. Meeting of the Society, 27 November 1939

UNDER the title of "The search for oil" I have given myself the task of setting down, first, a short review of the present distribution of oil production throughout the world; secondly, a description of the general nature of oilfields and of modern methods of exploration; and thirdly, an account of current exploration for oil in Asia. It is well known that the search for oil in all parts of the world is more active at the present day than ever before, and yet at the same time there is such a great potential over-production from existing oilfields that the economic structure of the industry is only supported by coordinated restraint on the part of the producers. For example, the great oilfields of the United States were given a fortnight's holiday in August of this year in order that an embarrassing situation caused by uncomfortably full surface storage might right itself. And yet one frequently reads in current journals of a coming shortage of oil supplies and of there being only fifteen years of oil reserves in sight. How are these apparent paradoxes to be reconciled?

The world's oil production

The table (p. 4) gives the distribution of present production, total production up to date, and an estimate of proved reserves of various countries in the world.[1] The outstanding points which emerge from a study of it are, first, how small a number of countries in the world contribute importantly to the total oil supply, and second, that of these only two, the U.S.A. and the U.S.S.R., are themselves important users. And what a curious, almost freakish distribution! It is easy to answer that the distribution is controlled by geological circumstances, but one's innate trust in the law of averages handicaps one in believing that Providence really has endowed the U.S.A. with such a dominating proportion of the world's oil.

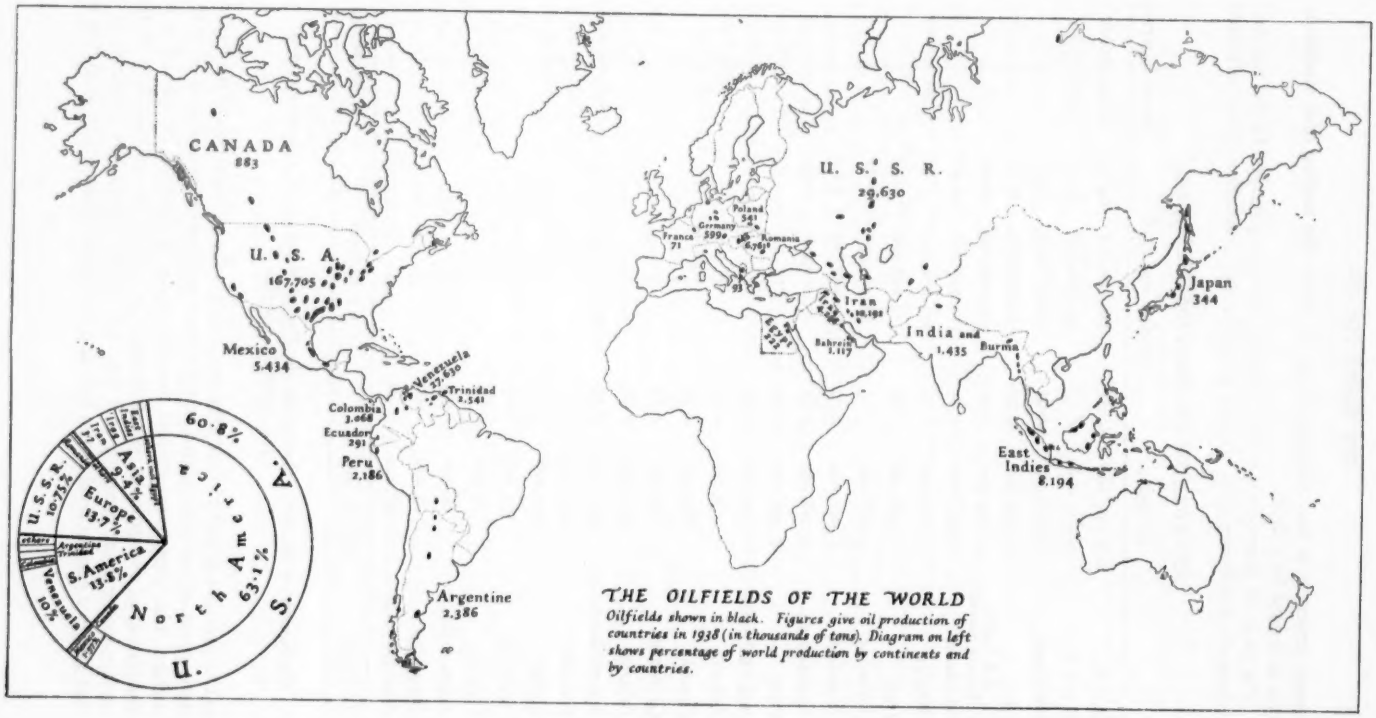
[1] Garfias: American Institute of Mining and Metallurgical Engineers. Annual Meeting, New York, 1939.

The nature of oilfields

Before continuing with this topic, and certainly before commencing an examination of the extent of proved reserves, I shall to a certain extent digress by describing the general nature of oilfields. For many years an acute controversy raged over the origin of petroleum, whether inorganic or organic, but of recent years evidence in favour of organic origin has become overwhelmingly strong. The trouble is that oil, being mobile, does not necessarily remain where it was formed and so allow one to examine the circumstances of its birth, as, for example, is the case with coal. Being a fluid it can, and often does, migrate considerable distances vertically and laterally through the rocks, and one can seldom be quite sure of its original provenance. In general terms it is now thought that oil is formed by slow chemical or biochemical decomposition of the remains of lowly forms of organic life entombed in sedimentary rocks. Circumstances may vary considerably, but marine or estuarine conditions seem a necessary condition for the formation of oil in important quantity. This means that these organic remains, whether seaweeds or sea grasses of whatever form, marine animal elements such as foraminifera or plant life such as diatoms, are entombed in the bottom sediments of shallow seas or estuaries under stagnant bottom conditions which prevent complete decomposition before burial. Subsequently this organic material is transformed, perhaps by bacterial action or perhaps by age-long chemical change, into small globules of oil and gas; and in the course of geological time, as the original muds are being compacted into shales or marls, these globules, together with a much greater quantity of original water, are squeezed out and find a lodging in any convenient porous stratum such as a sand lens or a porous limestone.

In this way a water-bearing porous stratum may carry globules of oil and bubbles of gas, though widely dispersed. The next phase is the concentration of this oil from a state of fine dissemination into what we in our short-term egoism call commercial oilfields. This concentration is primarily brought about by the force of gravity. Oil being lighter than water floats, and so the globules trickle up to the top of a given layer of sand, say 50 feet in thickness, until their further upward progress is sealed by an impervious cover of rock such as shale. If this rock layer were itself horizontal further movement of the oil would then stop, but this is seldom the case. In the course of geological time the layers of rock become tilted by processes of mountain building, and in front of the major mountain ranges of the world the stratified rocks are thrown into a series of folds or anticlines (Fig. 1). The crests of these anticlines become oil-traps for oil and gas which float up within a porous layer from the adjacent troughs or synclines. The oil thus concentrated along the summit of such an anticline is actually floating on water within its porous reservoir rock, as illustrated in Fig. 2, and if gas is present in greater quantity than can be kept in solution in the oil the excess gas fills the highest part of the anticline, forming what is known as a gas cap.

The most usual type of oil accumulation is under such anticlinal control. Another type is where the oil is concentrated in the higher edge of a tilted sandstone wedge, and such an occurrence is called a stratigraphic trap or shoreline oilfield. Yet further types are where an intrusive body of salt gives a



THE OILFIELDS OF THE WORLD

Oilfields shown in black. Figures give oil production of countries in 1938 (in thousands of tons). Diagram on left shows percentage of world production by continents and by countries.

domed structure to the adjacent strata, or where the sealing of a sandstone layer is caused by a fault.

The oil in its reservoir is under a certain pressure governed by the regional hydrostatic conditions (Fig. 2), and it carries gas in solution either saturated

PETROLEUM PRODUCTION (in long tons)

	In 1938		*Total to end 1938*		*Proved Reserves*
U.S.A.	167,705,000	60·81%	3,026,000,000	64·19%	2,000,000,000
U.S.S.R.	29,630,000	10·75	575,000,000	12·20	700,000,000
Venezuela	27,657,000	10·03	242,000,000	5·14	
Iran	10,192,000	3·70	125,000,000	2·65	
Dutch E. Indies Br. Borneo & Sarawak	8,194,000	2·97	119,000,000	2·52	
Romania	6,761,000	2·45	119,000,000	2·52	
Mexico	5,434,000	1·97	271,000,000	5·75	1,580,000,000
'Iraq	4,298,000	1·56	19,000,000	0·40	
Colombia	3,068,000	1·11	33,000,000	0·70	
Trinidad	2,541,000	0·92	23,000,000	0·49	
Argentine	2,386,000	0·87	25,000,000	0·53	
Peru	2,186,000	0·79			
India & Burma	1,435,000	0·52			
Bahrein	1,117,000	0·42			
Canada	883,000	0·32			
Germany	599,000	0·22			
Poland	541,000	0·20			
Japan & Taiwan	344,000	0·12	137,000,000	2·91	80,000,000
Ecuador	291,000	0·11			
Egypt	222,000	0·08			
Albania	93,000	0·03			
France	71,000	0·03			
Saudi Arabia	66,000	0·02			
Hungary	43,000	0·02			
Other countries	48,000	0·02			
TOTALS	275,805,000		4,714,000,000		4,360,000,000

The figures in the last column are the Proved Reserves on 1 January 1939 estimated by Garfias

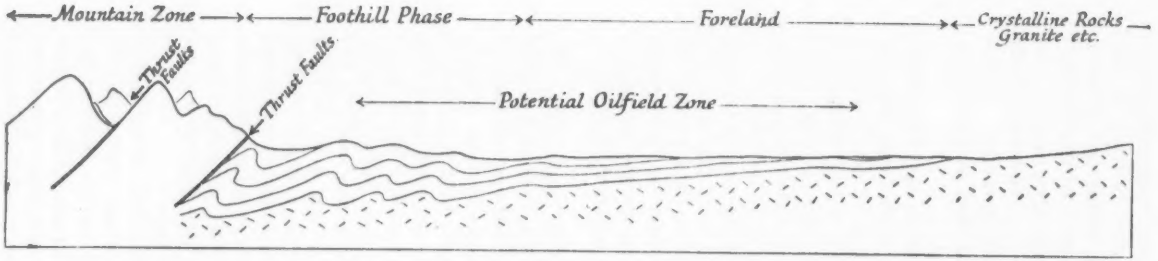
to this pressure or some lower pressure, and it is the combination of the hydrostatic pressure and gas content which causes gushers or fountains of oil at the surface. The homely example of the soda-water syphon can be quoted as an illustration of the process. When the well is drilled the oil may flow at the surface under great pressure or it may flow gently under low pressure, or it may rise to a certain level in the hole and no higher, from which level it must

be pumped to the surface—all depending on local pressure conditions and gas saturation pressure. The life history of an oilfield after discovery is first exuberant youth, then, as initial vitality declines, sober middle age, followed by a long period of tired old age with ever-decreasing productivity. The best results are obtained under conditions of controlled production whereby the initial flow is throttled down and both the gas and the water pressures, which are the motive forces of the oil production, are carefully controlled. A carefully managed oilfield may be made to produce several times as much oil as would be the case under wasteful conditions of control.

After complete exhaustion, what is the corpse of an oilfield like? The porous rock skeleton remains unaffected, as the oil has been drained only from the interstices between the sand grains of a sandstone or from between the grains or fissures of a limestone, and a large amount of oil still remains wetting the surfaces of these grains. Only about 20 or 30 per cent., on an average, of the total oil of a reservoir can be produced by ordinary means, but more is possible where a competent natural or artificial water flush or drive is operative. In some cases, particularly where the reservoir rock is a limestone, too rapid oil production may draw water up the fissure system and cause premature and unnecessary ruin of an oilfield; this happened in Mexico in 1922, as some investors may remember to their cost. Eventually it may be economically possible to mine the oil sands of exhausted oilfields to recover the residual oil, a process which, aided by high protection, is now in operation at Wietze in Germany.

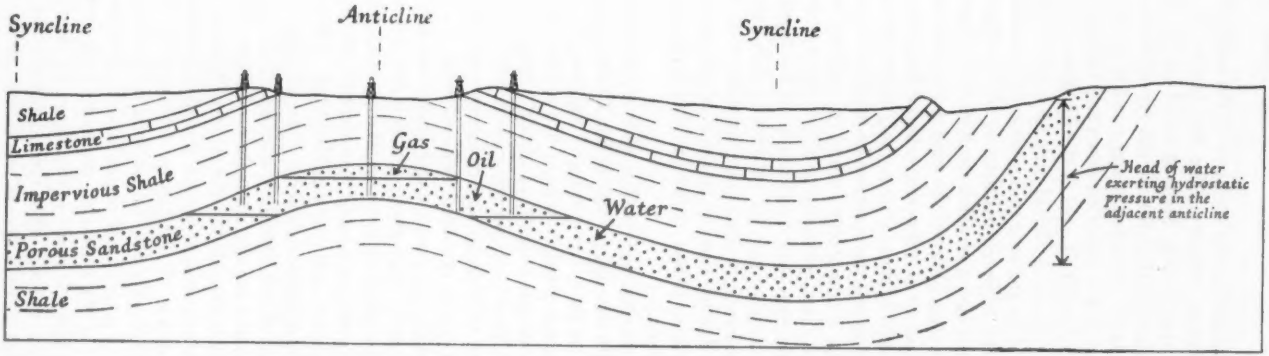
Oilfields vary within wide limits both in size and in productivity. The world's record for size is the oilfield of East Texas, which, in its nine years of life to date, has produced 205,200,000 tons of oil and is credited with an ultimate possible total of 650 million tons. It has a length of about 40 miles, an average breadth of about 7 miles, and 25,800 wells have been drilled. The world's depth record is a well in California which reached 15,004 feet. Such spectacular figures however are the journalistic scoops of the oil world and give a distorted impression of the average condition. Oilfields may be classified as giants, major fields, and average fields. In the first category, and not more than about a dozen oilfields in the world belong here, are fields which will give an eventual total of 100 million tons or more. Major oilfields, and even these are not too plentiful, are from 5 to 100 million tons, and average fields are under the 5 million mark. The number of oilfields in the world in the average category is about 1500, and the average size is about 500 acres, average depth about 2500 feet, average initial production per well about 10 tons per day, and average ultimate production about 2 million tons.

So much for the nature of oilfields. I shall now refer back to my table of production distribution and discuss the question of proved reserves and the prospects of the future. In the table the U.S.A. is credited with proved reserves of 2,000 million tons, or in other words about twelve years of supply at the present rate of production. This however refers only to proved reserves, that is, the estimated production yet to be drawn from known fields, and no allowance is made in this figure for new discovery. The rate of new discovery in the States is still a formidable one. But the present decade will show a considerable reduction in this respect on the previous, and this is in spite of great



Generalised cross section of a mountain system from high mountains to crystalline foreland

Fig. 1



Geological vertical section through a typical anticlinal oilfield

improvements in the technique of oil finding and of the depth capacity of drilling machinery (Fig. 3).

Many estimates have been made in the past of the total oil reserves, as distinct from proved reserves, of the U.S.A., and each estimate has in turn been disproved by subsequent experience, with the result that there is frequently a disinclination on the part of many to trust the common anticipation of a coming shortage of oil, a disbelief which gains strength from the large potential over-production at the present day. But notwithstanding past errors, there is no doubt on the part of all responsible American oil geologists, and my own study of the situation adds confirmation, that the bulk of American oil has already been discovered. Fifteen years' supply is already in sight and new discovery may provide for perhaps a further ten years, perhaps fifteen years, or perhaps twenty years, but that is the order of expectation. One must not conclude from this that the oilfields of the States will be exhausted within twenty to thirty years from now, because the rate of decline of old oilfields is so slow that it would be impossible to exhaust them in such a short time. But what it does mean is that there will be a decline in total production within a measurable number of years, and a realization of this salient fact is important for the theme of my paper. It is the realization of this fact by the large and powerful American oil companies that has caused them to intensify their search for new reserves of oil elsewhere in the world, and to compete actively for new concessions wherever they are to be had and in any countries having even remote potentialities, knowing that all the more obvious prospects have been taken up and explored long ago.

Before leaving the U.S.A. I must answer my earlier question of why that country should have such a dominating position in the world of oil. The answer is twofold: they actually have an enormous oil supply, and they have tried harder than any other country. I have already explained how oilfields occur in sedimentary basins, in the folded zones in front of mountain ranges, or in shoreline zones. The U.S.A. have a variety of geological provinces of various ages fulfilling these conditions, but that is not all. They have tried harder. Every modern device of exploration is rapidly accepted and utilized, but supplementary to both geologist and geophysicist is the wildcatter or the speculator who drills on "hunch" alone. And the wildcatter fulfils an important function. He has not only directly discovered perhaps 20 per cent. of the total oil of the States, including the biggest of all oilfields, that of East Texas, but he has also indirectly contributed to a greater degree in that both geologist and geophysicist make use of the information from his unsuccessful wells as a guidance for their own locations. A further important factor is that small oilfields which can be produced with profit in an intensively industrialized country would not be economically possible if remote from markets or existing pipelines.

Exploration methods

I have already explained in general terms the geological characteristics of oilfields and I shall now describe briefly the principles and working methods which lead up to the discovery of new oilfields.

In the first instance a country to be investigated must be examined in

Geological vertical section through a typical anticlinal oilfield

respect of its general geological nature. Countries which are composed exclusively of igneous or metamorphic rocks, that is to say, of granite or schists or gneisses, have no possible hope of containing any oil, and attention is directed solely to areas having a cover of sedimentary rocks (Fig. 1). The strata must have had a favourable development for the original formation of oil, must contain suitable porous rocks to act as oil reservoirs, and must be folded into

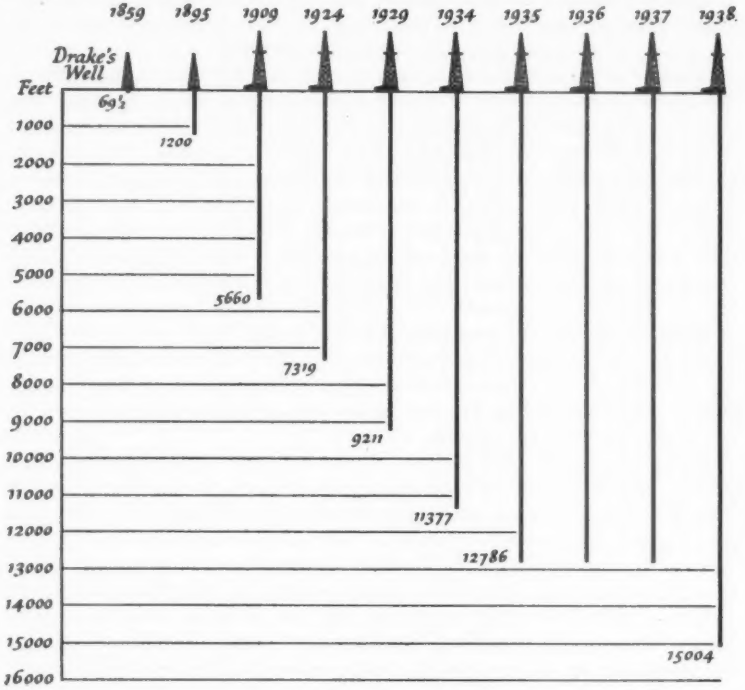


Diagram showing increase in depth of the world's deepest wells
(From Pogue, J.E. Economics of the Petroleum Industry, 1939)

Fig. 3

a suitable pattern for the accumulation of important amounts of oil. Unfortunately, science has not yet progressed so far that we can with certainty recognize primary oil-source rocks, but we can say that certain groups of rocks may come into this category and that others certainly do not; for this reason the oil geologist is greatly encouraged by outward indications of the actual, as distinct from the theoretical, existence of petroleum in the form of oil seepages, oil impregnated rocks, or of oil residues.

A preliminary geological survey investigates these various points and, in the case of relatively unknown countries, it is usually necessary to make a comprehensive geological map at the outset and an intensive study of struc-

tural and stratigraphical conditions must be made. During the early stages of this exploration, aerial photography has been used to great advantage during recent years. Not only can topographical maps, of sufficient accuracy for the purposes required, be drawn from these photographs but, in addition, much geological information can be deduced from expert stereoscopic examination of pairs of photographs. Rock outcrops can be marked, dip and strike determined, and faults detected; and the outline geological map thus produced is of great assistance to the subsequent ground survey. In many instances, particularly where outcrops are poor, structural deductions, which would be difficult or even impossible to make on the ground, are possible from a study of drainage pattern or of hill forms from the photographs.

A geological survey is dependent on sufficient rock outcrops, and in many foothill zones in front of main mountain systems, particularly in arid countries, the solid geology is well exposed. But sedimentary basins frequently fall in low-lying areas or alluvial plains, and in this case the solid rock structure is completely obscured from view by a mantle of alluvium, marsh, or tropical forest. When this is the case the capacity of the geologist is limited and he has to call on the assistance of the geophysicist for further help. By geophysics is meant any physical method of investigating the subsurface structure of the earth, and applied geophysics in this sense is a product of very recent years.

The methods used are based on gravimetric, seismic, or electrical principles, each of which has advantages by certain circumstances. The gravity method was the first to be developed, and an extremely sensitive torsion balance, invented by the Hungarian scientist Baron von Eötvös, was first used for oil finding by Dr. H. de Böckh, also a Hungarian. During the last few years a new type of gravity instrument, called the gravimeter, has been extensively used, and although the physical principles of the instrument are considerably different the final result for practical purposes is similar. These gravity instruments measure minute differences of the force of gravity throughout a given area, and it has been found that a large anticline, the core of which has rocks of higher specific gravity than its flanks, causes at the surface a slight increase in the value of gravity as compared to its surroundings. The effect may range from a few milligals to perhaps as much as 50 in the case of a major unit, but as a milligal is 0·001 cm/sec.^{2}, or approximately one-millionth part of the total force of gravity at sea-level, it will be readily appreciated that the instruments used are most highly sensitive and their manipulation is a matter of extreme care and skill. An inverted gravity result is obtained in the case of salt domes where the salt core of the dome is of a lighter gravity than the surroundings, and in this case the target which is required takes the form of a gravity minimum.

The geophysical method which is now perhaps the most usual is based on seismic principles. This is a type of echo sounding, but subsurface conditions are naturally much more complicated than is the case with the marine echo sounder. A small explosion is fired in a shot hole of 50 or so feet depth and the return vibrations, reflected from various harder rock groups at depth, are registered by groups of seismometers. The results are correlated and depicted in the form of contour maps which show the structural attitude of the various reflecting horizons. In some cases however the composition of the

rocks is not suitable for giving satisfactory reflections and it is necessary to use the refraction method. Its use requires a much larger charge of explosive, which in exceptional circumstances may be as much as 1–2 tons of gelignite, and the seismometer instruments are placed much farther from the shot point than is the case with the reflection method, the distance being as great as 10–15 miles.

In other cases certain electrical methods of surveying are used, although the conditions suitable for their employment are less frequent than with the methods already described. The electrical method measures the relative resistivity and conductivity of the various groups of rocks and provides a contour map of their structure.

These various geophysical methods do not, of course, determine directly the existence or otherwise of underground oil, but they do assist greatly in providing a structural picture of the subsurface by which deductions regarding the probability or otherwise of oil may be made, and they assist greatly in locating exploration wells to best advantage. They are however far from being a universal panacea and there are frequently many difficulties of interpretation of the results obtained.

During recent years a geochemical method has been attempted which deals more directly with underground oil. Small quantities of surface rocks or soils are analysed for their hydrocarbon gas content, and it has been found that minute escapes of gas, not detectable by ordinary means, may give a clue to underground oil accumulations. This method is at present at a stage of early development and much research work is required before it can be looked upon as an established method for routine application.

The hazards of oil exploration are well known to the investing public, but the reasons for them are probably less well appreciated. After as complete a survey of a potential oil region as is possible, using all geological and geophysical assistance, the average chance of success of an exploration boring cannot ever be rated, on the basis of past experience, as better than perhaps one in ten; but past experience has also shown that if financial resources can stand the strain of the nine unsuccessful efforts the reward from the fortunate tenth may be expected to give sufficient compensation.

Oil exploration in Asia

The intensity of exploration in various parts of Asia has considerably increased during recent years, and most of the large British and American oil companies are involved. British and British-Dutch companies have been actively engaged in the Asiatic field for many years, and many important oilfields have been discovered and developed; but the new interest now being taken by American companies is, as I have already said, based on the belief that American oil reserves will not stand the present rate of production for many years. The necessity to discover and develop additional reserves well ahead of demand forces the American companies to carry the search to whatever parts of the world offer even remote prospects. Exploration work under modern conditions is a lengthy and expensive undertaking, and the interval between the commencement of an examination of a new concession and the time when an oilfield is found and sufficiently developed for export

Faulted anticlinal axis, Agha Jari

Anticlinal axis, South Iran

Aerofilms, Ltd.

Air photograph showing a fold running from A to E through B, C, and D

Oil seepages in a creek at Masjid-i-Sulaiman

may cost many hundred thousand pounds in money and five or even ten years in time. For this reason exploration work must be years ahead of the necessity for the products which may emerge therefrom, and in many cases big oil companies reduce the hazards of expensive undertakings by pooling their resources and cooperating in the exploration surveys.

The countries, other than in North and South America and Europe, where exploration is at the present moment most active are Egypt, Sinai, Palestine, Syria, Arabia, 'Iraq, Iran, Afghanistan, Asiatic U.S.S.R., India, Burma, Dutch East Indies, Borneo, Sarawak, Dutch New Guinea, British Mandated New Guinea and Papua, Australia, and New Zealand. In many cases the chances of discoveries of importance are extremely speculative, but nevertheless wherever theoretical possibilities exist they are being exhaustively investigated. A large expenditure of money and effort may give insufficient or completely negative results; as examples may be quoted an American company's recent experience in north-eastern Iran and Afghanistan and the Shell Company's exploration survey in Papua, which was abandoned after £433,000 had been expended. An example of the opposite experience is the spectacular success of an American company at Bahrein. It would be quite impossible in the course of this paper to describe in any detail the progress of these extensive surveys, but a short résumé of the present position would probably be interesting.

Egypt, Palestine, Syria

The first phase of exploration in Egypt was in the years just before and after the World War of 1914–18, when about forty exploration wells were drilled in various places throughout the Gulf of Suez littoral. Two oilfields were discovered, Jemsa and Hurghada. After a very few years of spectacular life the Jemsa field declined and was abandoned, but the Hurghada field, discovered in 1913, is still producing, although at a steadily declining rate. Eighteen months ago however the persistent effort of the Anglo-Egyptian Oilfields, Ltd., was rewarded with a new discovery at Ras Gharib, 115 miles south-east of Suez. This discovery has greatly stimulated exploration in other parts of the Gulf of Suez area, northern Egypt, and Sinai. Geological and geophysical surveying is being actively carried out by British and American companies, and several new exploration wells are in the course of drilling.

Geological and geophysical exploration has been active in Palestine for a number of years, and several concessions have been granted in the coastal zone and in the Dead Sea region. Drilling is contemplated, but progress has been retarded by the recent troubles in Palestine. It is interesting to recall that the bituminous occurrences in and adjacent to the Dead Sea gave rise to its ancient name of Lacus Asphalticus.

Two deep wells are at present being drilled in Syria, one at Derro, close to Deir ez Zor, and one at Dubeyat, east of Palmyra. As yet no success has been recorded, but the work is continuing. Other exploration wells are also contemplated as the result of extensive geological investigations.

Iraq

The construction of the pipeline system from 'Iraq to the Mediterranean has been one of the most spectacular engineering achievements of recent

years. It connects the Kirkuk oilfield, discovered and developed by the 'Iraq Petroleum Company,[1] with the Mediterranean terminals at Haifa and Tripoli. The current rate of production is approximately 4 million tons per year, and the proved reserves of the field were sufficient to justify the enormous outlay required for the pipeline construction. Against this successful result may be put the fate of the adjacent concession of the British Oil Development Company in the Mosul area. This company drilled many wells in the extensive area south and north of Mosul and, although large amounts of oil have been encountered, its quality, owing to high specific gravity, viscosity, and sulphur content, proved such that its export is not an economic possibility. In the early stages much of the finance and material for this work was provided by Italian and German sources, but after many years of discouragement these countries withdrew their support and the further exploration is now being financed by the 'Iraq Petroleum Company. The total expenditure to date, and so far without economic return, amounts to several million pounds.

During the past year a further concession has been granted by the 'Iraq Government in the southern part of the country, but as yet its investigation has been confined to the initial geological and geophysical surveys.

Iran

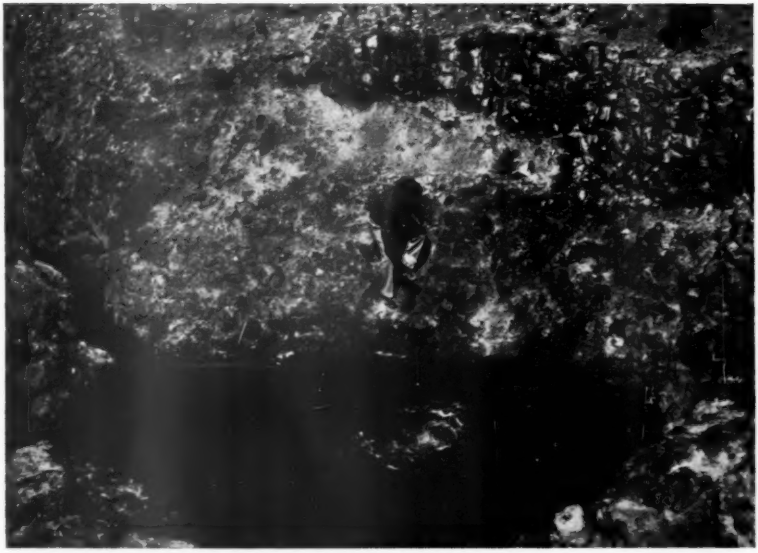
Iran ranks fourth among oil-production countries of the world, and its current output is slightly over 10 million tons per annum. The original concession was granted in 1901, but many drilling failures preceded the first success at Masjid-i-Sulaiman in 1908.[2] The pipeline from this field is 120 miles in length and serves a refinery and port at Abadan on the Shatt al 'Arab. In the north-west, a pipeline connects the fields of Naft-i-Shah to a refinery at Kermanshah which supplies local market requirements. The Haft Kel field was discovered in 1928, and during recent years other discoveries at Gach Saran, White Oil Springs, and Agha Jari have been registered. These new discoveries are required to maintain production and to offset the gradual decline of the older fields. Oilfield discovery in Iran is rendered particularly difficult by the unusually complicated geological conditions, and a large programme of geological, aerial, and geophysical surveys is continuously required.

Hitherto the oil production of Iran has been confined to these southern regions, but it is well known that oil indications and possibilities exist in the northern provinces of the country. Five years ago an extensive concession in northern and eastern Iran was acquired by an American company and several years were occupied in preliminary geological investigations. In the end however it was concluded that, although oil possibilities undoubtedly exist, the expectation of quantity in view of the remoteness of seaboard did not make oil export economically possible at the present time, and the concession was relinquished. During 1939 a Dutch company acquired a concession for minerals and for oil exploration over certain areas in central Iran.

[1] The control of the 'Iraq Petroleum Company is shared between the Anglo-Iranian Oil Company, the Royal Dutch-Shell, American, and French interests.

[2] The history of the development of this concession has already been described to this Society by Sir John (now Lord) Cadman under the title of "Middle East geography in relation to petroleum," *Geogr. J.* 84 (1934) 201–14.

Geologists examining oil-impregnated rocks



A seepage of thick oil with gas bubbling in the centre of the pool at Hit, 'Iraq

An exploration well at Yamaha, South Iran

An exploration well in South Iran

Kuweit, Bahrein, Arabian coast, Qatar peninsula, and southern Arabia

Drilling has been carried out at Kuweit for several years, and after an initial failure success was registered in 1937. Further wells are now being drilled, but as yet the extent of the oilfield has not been determined. The operating company is under joint British and American control.

An important oilfield has been developed by American interests on Bahrein Island, and its current production is approximately one million tons per year. The island itself is formed by a single anticline, so that in this case there is no expectation of other similar oilfields within the limits of Bahrein territory. A refinery has been erected on the island and a marine loading terminal serves ocean-going tankers.

Important concessions of considerable size in Sa'udi Arabia are also held by American interests, and a number of exploration wells have already been drilled in the Hasa province. So far one oilfield has been discovered at Dammam and is now beginning regular production and export. An oil-well accidentally caught fire last summer and was prominently reported in our press.

The Petroleum Concessions, Ltd., a subsidiary company of the 'Iraq Petroleum Company, hold a concession for the Qatar peninsula, which lies east of the Bahrein Island. Geological surveys have been in progress for some years and an exploration well is at present being drilled. Various concessions have been acquired to cover the greater part of south-eastern and southern Arabia. Geological surveys and air reconnaissance flights have been carried out during recent years and are still continuing.

Afghanistan

An oil concession of 240,000 square miles in extent was acquired by American interests in 1934, and extensive geological surveys were carried out during the following years. A number of oil indications are known, particularly in the northern part of the country, but it was concluded that, though oilfields might be possible, their size was not likely to be sufficient to justify the expense of pipeline development to the Arabian Sea coast. The local market is also not large enough to justify, for its own sake alone, the large expenditure necessary for exploration drilling. The concession was relinquished in 1938.

Asiatic U.S.S.R.

Developed oilfields of importance in Asiatic U.S.S.R. are confined at present to three regions, the coastal zone of the Caspian Sea south of Krasnovodsk and including Cheleken Island, the Ferghana valley in Kirgizia, and Sakhalin. The last named produces about 400,000 tons per year, and Japanese companies participate in the development. Exploration is being actively carried out in various parts of the immense territory of Asiatic Russia and many new discoveries must be anticipated. The Ferghana valley, being the centre of the cotton-growing belt with silk and mineral industries in addition, has a large local consumption which it is expected will be completely supplied from local sources within a few years. Some small fields, though of low-grade oil, have also been reported in Tajikistan close to the Afghanistan border.

The surroundings of Lake Baikal are now being investigated, and theoretically oilfields are possible throughout extensive areas of Siberia. Transport difficulties will however handicap any early development of prospects in remote areas. Reference should also be made to a small producing well in the Taimir peninsula within the Arctic Circle.

The bulk of both present and past Russian production has come from the European side, but the possible future resources for both European and Asiatic U.S.S.R. are immense. Garfias (see p. 4) has given the proved reserves as 700 million tons, but Gubkin has published estimates far in excess of this. He gives a possible total, *i.e.* proved plus possible, of 6376 million tons, and while this may be over-optimistic there is no question of the importance for the future of the oil reserves of the U.S.S.R.

India and Burma

Oil production from India is confined to the Potwar basin area near Rawalpindi, where there are two small producing fields—Khaur and Dhulian—both operated by the Attock Oil Company, and in Upper Assam, where the Assam Oil Company, a subsidiary of the Burmah Oil Company, has a small field at Digboi. In both these areas exploration work has been active for many years, and many other exploration wells have been drilled, but hitherto without further success.

During the past two years investigations into oil possibilities have been carried over larger areas, both in north-eastern and north-western India, but no deep drilling has as yet been undertaken. Both British and American companies have acquired exploration licences. The areas with theoretical, though very speculative, possibilities lie partly in the vast alluvial plains and partly in the foothills. In the former, exploration has involved extensive geophysical work on the part of the operating companies, and in this connection the geodetic work of the Survey of India has been of great assistance. Geological surveys, assisted by aerial mapping, are being carried out in the foothill regions in areas where sufficient outcrops exist to make surface geology possible.

The oil production of Burma is drawn from three principal fields and, in spite of a considerable programme of exploration drilling carried on for many years, no recent addition of importance to known reserves has been made. Exploration work however is being actively pursued in spite of all discouragements. The possibility of employing geophysical methods in alluvium-covered areas now makes oil exploration practicable in areas which some years ago would have been completely disregarded.

Dutch East Indies, Borneo, and Sarawak

Oil production from these islands amounted to 8,194,000 tons in 1938, which was drawn from a large number of individual fields. Most of the existing fields are already in an advanced state of decline, but new discoveries offsetting this are being made from year to year and exploration work is being actively pursued.

Dutch New Guinea, Papua, and Mandated New Guinea

An extensive concession in Dutch New Guinea is being explored by a company in which American, British, and Dutch interests are represented. A wide

aerial survey was carried out at an early stage, and the surface geological mapping has been greatly assisted by photo-geological interpretation from the aerial photographs. Geological and geophysical surveys followed and the exploration drilling stage is now commencing. Up to the beginning of this year about 1½ million pounds is reported to have been spent on this concession.

A number of oil indications are known in Papua and New Guinea and led to an investigation and exploration drilling programme in the war years of 1914–18 and subsequently. The results however were uniformly disappointing, partly due to technical and drilling difficulties, and no work was carried out for a number of years. Following on recent changes in petroleum legislation on the part of the Australian Government, a fresh attack on the possibilities has recently been commenced and considerable concessions have been acquired by American, British, and Australian companies. I have already mentioned that the Shell Company have abandoned their interest in another area in Papua, after surveys involving an expenditure of over £400,000 had been carried out. The other concessions are now being actively explored and the drilling phase will soon be reached.

Japan

Japan, including Taiwan, produced 344,000 tons of oil in 1938. For national reasons of self-sufficiency Japan has been making strenuous efforts to increase her indigenous production for many years, but new discoveries and deeper oil horizons in existing fields have not done much more than offset the decline of the older fields. In 1937 a well was drilled to a depth of 11,502 feet at Kinsin in Taiwan, and several oil sands are recorded below 10,000 feet.

In the foregoing pages I have attempted to analyse the underlying factors governing the present-day search for additional oil reserves throughout the world, and particularly in Asia. The United States has supplied 64 per cent. of the total oil production of the world up to date and is still producing 61 per cent. She has at present a potential output considerably in excess of market demand, and restrictions on production have been imposed in most of the individual States. It is expected however that this is a passing phase as, with more and more fields falling into decline, more and more new discoveries are required to offset this cumulative factor, and it is unlikely that the discovery rate of the past two decades will be repeated. The proved reserves of the United States have been estimated at twelve years' supply at the present rate, but new discoveries can be expected to extend this to twenty or thirty years, or perhaps even longer. A decline in total production from the great oilfields of the States is however in sight within a measurable number of years, and a realization of this fact is responsible for the recent intensification by American interests of the search for oil supplies elsewhere in the world, knowing that five or ten years are required to explore and develop a foreign concession to the point of commencing export. Exploration is particularly active in South America and Asia.

Asia is at present producing 9·4 per cent. of the total world supply, but without question this proportion will increase substantially in future years. British and British-Dutch companies have been active in oil exploration in Asia for

many years and have many notable discoveries to their credit. Recently however the search has been considerably intensified and American interests have entered the field on a much larger scale than hitherto.

The geographical importance of oilfield discovery and development in Asiatic countries does not require emphasis. The necessary preliminaries of aerial, geological, and geophysical surveys enormously enhance our scientific knowledge of hitherto little known parts of the world, and the subsequent opening-up of inaccessible regions by oilfield development can bring about far-reaching sociological changes by the introduction of money, employment, and quick means of communication by road and by air. The search for oil is playing an ever-increasing part in the Westernization of many parts of the East.

Asia, with 55 per cent. of the world's population, has less than 5 per cent. of its oil consumption, but this is a changing circumstance. Hitherto most of the oilfields in Asia have been developed for export and only areas adjacent to coast-line, or oilfields of a size to justify the large expense of pipelines to seaboard, have been developed. As mechanization progresses and as more and more motor roads are built and used, the internal market becomes increasingly important and will lead to oilfield development for its own sake alone. We are now ceasing to gape at the superficial changes effected by the impact of West upon East—the tribal shaikh driving across the desert in his expensive American car, Arabs in Jidda listening to broadcasts from European wireless stations, Iranian cities cut across by boulevards modelled on European pattern, and countless such familiar incongruities that demonstrate the intrusion of Western behaviour into Asia. The West has not only produced the pattern of modern life but, in countries where oil royalties form a substantial part of the yearly budget, the wherewithal to copy it. The movement is gradual, but now inexorable. How far habits of life will change habits of mind is a matter for conjecture . . . but with this thought I seem to be diverging too far from my geological analysis of the search for oil.

DISCUSSION

Before the paper the PRESIDENT (Field-Marshal Sir PHILIP CHETWODE) said: The Asia Lecture was founded in 1924 by the benefaction of Mr. P. L. Dickson, a Fellow of our Society, and provides in every other year an honorarium for a lecture upon some topic in the geography of Asia. A list of those who have delivered the Asia Lecture in former years shows that our interpretation of the Founder's terms is wide, and on this occasion we are fortunate in having Dr. G. M. Lees, the Chief Geologist to the Anglo-Iranian Oil Company, to inform us on the present state of that romantic, speculative, and intensive search for oil which has, as we know from former lectures given by Dr. Lees and his colleagues, incidentally contributed so much to the geography of many parts of Asia.

Dr. Lees then delivered the lecture printed above, and a discussion followed.

Sir ERNEST WILTON: There are some large depots of oil which belong to a German company, stretching across Chinese Turkistan. They are only depots; I do not know where the oil comes from.

Dr. LEES: That is merely a trading concern which does not own any oil-

fields. Actually, the Germans have played very little part in the development of foreign oilfields. That is perhaps strange, but it seems that their minds do not work favourably towards exploration. They are over-scientific and not good speculators. The American oil companies, of course, take first place in this respect and the British second. The Germans are almost nowhere, and the same applies to the Italians. Of recent years the Germans have been handicapped by lack of finance. In the case of the Mosul concession they worked for some years, but they were unable to stand the pace financially, and withdrew. But even before 1914 the Germans played a relatively small part in exploration for oil.

Mr. A. R. HINKS: May I ask the lecturer whether the great knowledge of geology which is obtained in the course of the expeditions eventually becomes public property, or is it locked up for ever in the archives of the oil companies?

Dr. LEES: Most of it eventually becomes public property. Several papers by explorers in oilfield work have been given to this Society and a large number of geological papers have been published. In many cases the work done is recorded as confidential for a number of years. There is usually some competitive aspect which prevents one from telling the whole story as it is being unfolded, but at a later stage there is no reason why the scientific results should not be made public, as is usually done. In many instances there is a concessionary obligation on the part of the exploring company to hand over all the geological reports to the Government of the country concerned.

The PRESIDENT: It is obvious, especially in view of the growing use of the internal combustion engine, that the consumption of oil is reaching astronomical figures. Does Dr. Lees consider, as a result of his knowledge of the oilfields, that the supply will keep pace with the development of the internal combustion engine? There is no doubt that in a few years' time the number of aeroplanes in use will be doubled. Or does he think that eventually it will be necessary to resort more generally to the use of producer-gas, or low-temperature distillation, or some other alternative of that nature?

Dr. LEES: That is a somewhat involved question. The life of oilfields as we know them at present is not likely to be lengthy. The United States' supply will last for thirty, forty, or fifty years, perhaps longer; perhaps not so long. The remainder of the world, particularly areas in South America and Asia, has produced hitherto a lesser percentage of its total oil than has the United States. Whether the oil supply lasts for fifty or one hundred and fifty years, it is a definitely limited amount. It is being rapidly exhausted. Compared with the resources of coal, the oil supply will be very short. We have in Great Britain coal resources in sight which will last for about five hundred years at the present rate of production, without taking into consideration the possible discovery of coalfields at present unknown. So that the life of oilfields, taking the long view of history, is a passing phase.

What will take their place? Well, there are several possibilities. After oilfields have been developed, and the wells have been drilled and have produced until they are dry, there is still an enormous amount of oil left in the ground. The portion of total oil in an oil sand which can be produced by present methods is perhaps a quarter, or one-third, and seldom more than half, of the total amount of oil in that sand. It will probably be economically possible at a later stage to mine the oil sands of a number of the old oilfields, like the tailings of gold mines. In fact, mining of exhausted oil sands is being carried on in Germany to-day at Wietze. Highly protected markets make it possible to mine that sand from a depth of about 2000 feet, bring the oily sand up to the surface, wash it clean, and recover the last dregs of oil from it. That will be possible in the case of many of

the shallow oilfields after their exhaustion by normal methods, but that only becomes profitable when a shortage of oil puts up the whole price structure and renders this more expensive method possible. This secondary recovery will extend the life of some of the oilfields, but not the world supply for more than a few years.

Then there are very extensive deposits of oil-shale in many countries of the world. In Scotland there is an oil-shale industry which is now only possible because it is protected in the home market, but again, as soon as a shortage becomes felt, oil from shale will be economically possible on a much larger scale.

Oil from coal is possible. Oil from coal is a feasible proposition at the present day, given a high protection. As soon as the naturally produced oils begin to dry up the oil price levels increase, we have oil from coal, oil from oil shale, from mining of exhausted oil sands, and presumably the future will be able to look after itself for the balance. In a hundred years' time electricity, coal, and gas will have taken over many of the present functions of oil, but the transition will be gradual. I have forgotten who it was, but some one once asked: What has posterity done for us? I look on posterity as able to shift for itself when the time comes.

Mr. MICHAEL SCOTT: Is there no speculation in oil in Western, Central, or South Africa?

Dr. LEES: I omitted from my paper any mention of Africa (other than Egypt) as being rather far removed from Asia. There is a certain amount of work going on round the fringes of Africa. A great part of Central Africa is occupied by crystalline rocks and comes into the impossible category, but there are certain prospects round the fringes. Exploration is at present being undertaken in the Gold Coast, Nigeria, and French Equatorial Africa, and for many years an American company spent a large amount of money in Angola without success. In South Africa there are some oil seepages, but so far no survey of the geological circumstances has made the prospects seem very promising. There are certain rather vague possibilities in Portuguese East Africa; Kenya and Tanganyika have also recently been explored for oil without result.

The PRESIDENT: It only remains for me to thank Dr. Lees on your behalf and with all my heart for what is in these days of war an astonishingly interesting lecture.

You perhaps heard last evening the Prime Minister broadcasting. He had been asked to dispel the feeling that has obtained among many people in Great Britain, that we are not trying to hurt the Germans; that we should undertake a really big offensive. Mr. Chamberlain said that we have had the two most fortunate months in the history of the British Empire. That is the truth. Owing to that piece of good fortune it has been possible to move oil about with very little interference; we have had the use of the Mediterranean with the pipeline at Haifa; the use of the Indian Ocean and of the Red Sea and the Suez Canal, all without interference. What that has meant to the British Fleet, and to France especially, who wanted that oil, is out of all computation.

I now ask you to pass a hearty vote of thanks to the lecturer for having told us so clearly how the commodity without which we cannot do in these days is found.

FORMAL WRITING ON MAPS

C. B. FAWCETT

Meeting of the Society, 6 November 1939

FOR the last twenty years I have been closely concerned with the study and interpretation of maps of many kinds. Such work compels a consideration of the symbols used on maps, and it is from the point of view of the map-user that I have come to the conclusions here presented on a particular group of these symbols, the letters and figures written or printed on the map.

Writing on maps differs from other formal writing, and from most printing, in that it must be adjusted to certain special characteristics of its background. The map is made up of a large number of other symbols whose positions are fixed, so that the writing which is to be added must be adjusted to them, thus becoming subsidiary matter on a surface already more or less fully occupied. In accommodating the words to the positions of other symbols, particularly those which they name, they may have to be written at various angles or in curves, and may need to be interrupted, or extended, or compressed over varied spaces and lengths. The topographic map must moreover be capable of being read in any position when oriented in the landscape; it should be possible to read any of its symbols in any position, upside down or on its side, as well as in the normal upright posture. Legibility should be the aim of all designers of symbols for writing and printing, except for that insignificant part which is purely ornamental; all the special needs of map-reading strongly reinforce the need for it. And on a map already carrying many other symbols legibility is, even more completely than in ordinary print, so essential that every other consideration should be subordinate.

The writing on a map is usually regarded as a map symbol in itself. It conveys directly the name of some feature, *e.g.* a town, and by the size and character of the writing it can also convey some other information about that feature, *e.g.* the size and/or the administrative importance of the town. So there is need for several different styles of writing the letters and figures, 26+9 symbols, of our alphabet, which we may speak of as so many "alphabets," for use on maps. Each different alphabet can convey, as a map symbol, additional information concerning the feature whose name it gives directly.

In designing such alphabets one must of course think of each symbol as it leaves the draughtsman and the press: fresh, cleancut, and complete. But in judging its effectiveness for our purpose, think of it as it will appear on a map which has been folded, creased, and more or less soiled by use. We need writing which will still be legible after such treatment; and it is by its legibility under such conditions in the field that map writing is to be judged. The frequent interruption of the writing by other symbols is another factor to be considered in the design of alphabets and words. In respect to the letters and figures, it leads to a first suggestion that the designer should aim at producing symbols that can still be read accurately even if only a part of them is left visible. Generally the larger part will be left; but it may be suggested that the designer should aim at legibility of a half. Such a requirement imposes a difficult task

on the designer, especially as it is very desirable that the reader should be able, in case of need, to decipher such a fragment of a symbol in any position. With letters the reader may often be helped by the context, *i.e.* on a map by the other letters of the word. This aid however is at its minimum in reading proper names, and the context gives no help in reading figures, *e.g.* the knowledge of three figures, as 35–7, of a four-figure number gives no clue to the missing figure. Hence it is even more important for figures than for letters that each symbol shall be legible, even if only part of it is visible. On a map the context may be practically lost as an aid to legibility if the word is widely spaced or badly interrupted; and it may be of little use in deciphering strange names. The map writer should not count on any help from the context of his symbols.

Before considering particular letters or figures it may be well to list some of the more important variables which are at our disposal for the design of simple alphabets. For ornamental alphabets, such as "Old English," there are many other variables; but here I propose to consider only plain lettering. The chief variables are:

Size.

The proportion of height to width in each letter.

The thickness of the strokes. These may be even, *i.e.* all of the same thickness, in which case it is still possible to differentiate alphabets by the proportion of the thickness to the length of the stroke. It is rare to use more than two thicknesses in one letter; but it is then possible to have different relative thicknesses, and different proportions of each to the length of the stroke, and so to obtain different alphabets.

Slope.

Serifs. These can be varied very widely in size, in thickness, and in proportion to the strokes to which they are attached. Where serifs are not used we have the sanserif alphabets.

The lengths of "tails" above and below the line, for minuscules or small letters only, and the relative size of minuscule and majuscule in the same alphabet.

Shading in the letter, for large letters only.

The spaces within some symbols, whether wholly or only partly enclosed, are also of great importance; and they must be as carefully designed as the strokes which enclose them. The spacing of letters and words is of comparable importance as a factor in legibility. These variables are sufficient to allow the design of a very large number of alphabets, all of which may be plain and legible and yet sufficiently distinct from each other to serve as map symbols. Of those mentioned only the serifs complicate the form of the symbols.

Some fairly obvious and important conclusions follow from the fact that legibility of single symbols, and even of parts of symbols, is here regarded as the paramount aim of the designer of alphabets for use on maps.

(*a*) Between letters and figures of similar form the differences should be emphasized and the resemblances minimized. Hence we should avoid as far as possible the repetition of identical strokes in different symbols. This is the exact opposite of some types of artistic writing and of the writing taught a

generation ago when letters were regarded as made up of a very small number of elements (the pothooks and strokes and loops of the first writing books) and the designer tried to use as few different strokes as possible, a practice which made for ease in writing but not for legibility.

(*b*) In any one symbol excessive symmetry is undesirable. The letter and figure o is normally perfectly symmetrical about its central point; and several others are symmetrical about one, or in some cases more, axes. This symmetry is usually a point of resemblance between different symbols, and it should be kept to a minimum if we are to obtain maximum legibility.

(*c*) The very thin stroke, the hairline, which has often been used in the past, should not be employed in any case. At its best, when it is new and perfect, it imposes a needless strain on the eye of the reader; and it is the first part to be lost as a result of wear and tear. The hairline is an abomination wherever legibility is desired.

(*d*) The serif is, in essence, merely a device for emphasizing and tidying up the end of a stroke; any exaggeration of it tends to distract the eye from the symbol itself, and so to reduce legibility. Thus serifs should be small in proportion to the letters, and must never be allowed to overshadow the strokes to which they form terminals. All strokes should have definite ends; one which merely fades away into a fine point akin to a hairline shares the disadvantages of that almost invisible, and so illegible, stroke.

(*e*) Any ornamental flourishes, or other strokes or marks which are not essential parts of the symbol, are like exaggerated serifs in that they reduce legibility by distracting the reader's eye. Such additions should be rigorously excluded.

From (*a*) it would follow, for example, that in figures the lower parts of 3 and 5 should be distinctly different curves; and the 6 and the 9 should not be identical in form, since in that case they can only be distinguished from each other by reference to some other symbol which defines their position; and obviously it should be possible to distinguish a 6 from a 9 in any posture. One of the first desiderata in the design of an alphabet for use on maps is the avoidance as far as possible of exact repetition of identical elements in the symbols and, as complementary to this, the emphasis of differences between those symbols which may be liable to confusion with one another in whole or in part. We want writing such that, when it is complete and clean, "he who runs may read" and also that, when it is soiled and worn, it may still be deciphered by the careful reader. The first of these aims is relatively easy to attain, though it demands care; the second is the more difficult, and attempts to attain it have led to many modifications in the details of the symbols.

Some of these points are illustrated by the capitals shown in the alphabet (Fig. 1), which is an attempt to reduce the letters to their essential elements. These are plain block letters, upright, of even thickness, and sanserif. The thickness of the strokes is one-tenth of the vertical height of the letters.

The letters are grouped according to the elements of which they are built up. In group 1 there are straight strokes only; in 1*a* only verticals and horizontals; in 1*b* verticals and sloping lines; and in 1*c* the strokes are mainly sloping with some horizontals. The six letters of group 2 are formed by

combinations of straight lines and arcs of circles. And in the five letters of group 3 curves are dominant; but not all of them are circular. In group *1a* the vertical strokes are all, unavoidably, identical. The horizontals differ in position and in length, and so provide adequate differentiation among these letters. These horizontals should also be compared with those in R, P,

Fig. 1

B, and D below. Among the letters in group *1c* the angles of slope of the main strokes of A, V, and W are all different; and the mid-point of the W is at only seven-tenths of the height of the letter, to increase the differences between these letters. The angles between the sloping strokes of A, V, W, X, and Y are all different; so also are those of M, N, and K. The difference in length of the two horizontals of Z increases the distinction of that letter from N on its side. It should be needless to add that W and M are totally

distinct; it is only in the poorest of lettering that an inverted M can be read for a W, or *vice versa*.

Group 2 consists of six letters, J, U, R, P, B, D, in each of which there are both straight and curved strokes. All these curves are here drawn as arcs of circles. J and I are closely associated in their history and functions, as well as in their form. In this country the J normally differs from the I only by the small leftward curve at its foot, and obliteration of this small part could cause confusion; here there is also a small leftward projection at the top, on the model of some continental lettering and the typewriter's small j, to obtain more difference between these two letters. The others are drawn as shown in Fig. 1; and the indication by dots of the centres of the circles whose arcs form the curved parts of these letters, and also of those in group 3, may help to indicate some of their differences. The curve of the D is made up of two arcs with different radii and centres. The C is also made up of arcs of two circles of different radii and centres, joined by a very short (one-tenth) straight stroke. The curved part of the G is also of two arcs; but with the centres differently placed, and no straight stroke. Both are kept open, especially the C, to emphasize their differences from O; this is further emphasized by the directions of their curves, and if produced to meet they would form loops of shapes quite different from that of the O and from each other. In the S there are arcs of four circles, though only two centres. The O, and the main part of the Q, are drawn as ellipses rather than circles because the circle is so convenient, and so much used, as a map symbol that it seems worth while to avoid using it as a letter or figure. In this alphabet these two are the only curved letters whose curves are not all circular arcs. The commonest confusion of O is with D, as seen often on motor car number plates; hence the emphasis on quite distinct curves for these two letters.

There are no serifs. The free ends of all the straight strokes are either horizontal or vertical. Of the curved strokes three are terminated by vertical ends, in S and G, and the rest have square ends, *i.e.* they end on a radius of the curve, in C, J, and Q.

In this alphabet there are still sixteen identical vertical strokes in thirteen letters, H, M, and N each having two. Also the sloping stroke of the Z is identical with one of those in X. But no other two strokes are identical. The top horizontals, which appear in T, F, E, and Z, differ in length, as do those at the bottoms of L, E, and Z; while the middle horizontals of H, F, E, and A differ in both position and length; and the similarly placed parts of R, P, and B are neither horizontal nor identical. The identities between halves of different letters are few, except that a half of the I is identical with corresponding parts of several other letters, such as L, T, H, F, M, N, K, and U. Apart from I, the top half of L is identical with the bottom half of T. Among the rest of the letters no two halves are identical; the nearest approach being that the right half of D is a mirror image of the left half of G.

If this is a complete statement of the identities, all of them are due to the unavoidable retention of the straight vertical stroke in more than half the letters, though in only eight cases do such a stroke or strokes form a full half. This alphabet goes some way towards making it possible to identify a letter only half of which is visible.

It is clear that other alphabets can readily be derived from this stripped one by varying the relation of thickness to length of stroke, writing at a slope from the vertical, using different thicknesses, and adding serifs. The thickness may be varied by using thinner strokes, which give a lighter writing, or thicker strokes, which give heavier writing. In the latter case it is important that the spaces wholly or partly enclosed within a letter, as in A and R, shall be kept sufficiently open to avoid serious loss of legibility. In no case should the width of such a space be less than the thickness of the strokes which enclose it. For the smaller of the spaces in Q and B this minimum can be reached very easily if the writing is made heavy. It sets a practical limit to the thickness of the strokes, beyond which writing becomes less legible as it becomes heavier. The same considerations point to a corresponding minimum of space between letters in any one word or group.

With the thick strokes of heavy writing the ends can easily be made clear, rendering serifs unnecessary; while if serifs are used they tend to become clumsy, to confuse the form, and to close up openings. But in lighter writing the use of thin strokes may make it desirable to define their ends by serifs, even though, since all serifs are much alike, any exaggeration of them tends to increase resemblances between different letters, and so to diminish legibility. Serifs should only be used where they can be kept so small that they do not interfere with clearness.

Some of the lower-case symbols are precise miniatures of the corresponding majuscule, but for a majority of them tradition has developed a somewhat different form. The grouping is again according to form, and the groups are not made up of the same letters as those of the first alphabet.

In group 1*a* are the straight-line letters. Except for k and y these are miniatures of their capitals. The k differs only in having its vertical continued above the line, and the y in that its tail continues the slope of the right-hand part of the top instead of being vertical. In group 1*b* the i and the j bear similar relations to their capitals, but there is a departure from tradition in the omission of the dots. In actual map reading I have found on many occasions that other symbols, *e.g.* for houses, are sometimes confused with these dots. It seems generally desirable that each alphabetic symbol on a map should be a single, continuous, and compact mark. Detached fragments of letters are confusing to the reader; and some experience with topographic maps of countries of central Europe has convinced me that diacritic marks forming part of, but separate from the main body of, the alphabetic symbols are a very fertile source of confusion. These dots over the i and j are the only marks of the kind in our normal English alphabet. The fact that they are not used over the capital letters I and J is evidence that they are not essential. Hence I suggest that in the formal writing on the map they should be omitted. The other letters of group 1*b* are of usual form.

In group 2 are the letters including two or more vertical strokes. Here differentiation is increased by using different spacing of the uprights, a hint from the typewriter.

Group 3 consists of five letters which in ordinary script have the loop in common and are differentiated only by the form and position of the upright stroke. Here it seems desirable to increase the differences, especially within

the pairs b and q, p and d, the members of which are often so written as to be merely inversions of each other. This is done to some extent by using four forms of the loop, in lieu of one, and by variation in the tail below the line, though it seems that still more differentiation is desirable within this group.

Group 4 includes letters mainly made up of curved strokes. Here the c, o, and s are miniatures of the capitals. The a avoids the form with one large loop which is too easily confused with d. For a similar reason the Greek form of e is preferred to the looped form because the latter is liable to confusion with both c and o when the letters are soiled or worn.

In designing the figures distinct forms have been used for the six totally enclosed spaces in the 4, 6, 8, 9, and 0. The differences between the 3 and the 5 and between the 6 and the 9 should be noted. The last is the most obvious departure from customary forms, and the result is not altogether satisfying. It may also be noted that all the figures are of the same height. For legibility of the figures the clearness and proportions of the loops and of the partly enclosed spaces is of particular importance; a heavy writing which diminishes these becomes difficult to read.

I have also designed a second minuscule alphabet which differs in the proportion of the height to the width of the symbols, and introduces some other forms which seem worthy of consideration. Among these are the h, in which the second upright is sloped a little, and the d, which is made more different from its companion looped letters by an approximation to the form of the Greek δ. In the figures the loops of the 8 are modified.

These alphabets are merely illustrations of the application of the conclusion stated above: that the aim of such writing should always be legibility. If we aim consistently at the greatest possible legibility, under the somewhat difficult conditions of map writing, the other graces, of good proportions, clearness, and simplicity, which make writing beautiful, will also be attained.

DISCUSSION

Before the paper the CHAIRMAN (Mr. W. L. SCLATER) said: This afternoon Professor Fawcett, of the University of London, is to open a discussion on "Formal writing on maps." Without more ado I call upon him to address us.

Professor Fawcett then read the paper printed above, and the following contributed to the discussion:

The CHAIRMAN: Major-General MacLeod regrets that his duties prevent his being present this afternoon. He has however sent a communication which the Secretary will read.

Major-General M. N. MACLEOD: Professor Fawcett has started from the assumption that the only consideration affecting printing on a map is that it should be as legible as possible. I suggest that this requires some qualification and that the overriding consideration in cartography is the clearness and legibility of the map as a whole. Choice of lettering is only one of the elements in the design of a map, which is influenced by many other factors, such as the scale, the character of the country portrayed, and the uses to which the map is put. In the case of large-scale maps, like the Ordnance Survey 1/2500 and 6-inch plans, there is generally plenty of room not only for names but for a certain amount of descriptive matter. One of the chief considerations in the choice of type is its suitability for the processes used in printing, in addition to its suit-

ability for conveying special kinds of information. These maps, for example, show many kinds of administrative boundaries, and the areas defined by these overlap one another to such an extent that it is, I believe, a very considerable convenience to the map user to be able to identify any particular kind of administrative area by the kind or style of lettering used for its name. These maps illustrate also, though in a negative manner, the advantages of paying attention to artistic and aesthetic considerations.

Going to the other end of the scale, namely the design of small-scale maps, the cartographer is generally faced with the difficulty that he cannot insert any writing at all without tending to obscure topographical detail. The problem is not only to keep writing legible, but in many cases to make it as inconspicuous as possible, consistent with reasonable legibility. Descriptive writing has to be economized by the use of conventional signs and symbols, and names of minor importance may have to be omitted altogether unless they can be written in such a manner as not to obscure topographical detail of greater relative importance. In other words, the style in which they are written should be one which enables them to be found only when looked for, and this, I think, is better achieved by an upright hairline sanserif style, with a fairly open face and well-formed letters, than by attempting to use very small italic writing as is the common practice at the present time. For much the same reasons I think there are decided advantages in making the style of the lettering indicative of the character of the object or feature described. This is the principle adopted in the Carte Internationale du Monde au Millionième, and though I know many people criticize it as inartistic, I myself think that it makes for clearness in the map and is therefore to be commended. I appreciate that there is nothing in Professor Fawcett's proposals which need be inconsistent with the above, but I think that his objects should be attainable without considerable departures from the classical forms of lettering to which we are all accustomed and which we associate with artistic merit.

Professor E. G. R. TAYLOR: I only had an opportunity of studying the lettering just prior to the lecture. While I congratulate Professor Fawcett on his ingenuity it seems to me that aesthetic considerations must be borne in mind. A large part of the alphabet really is hideous; in particular the sudden appearance of the Greek ϵ in the alphabet shocks one. When studying the lettering I remarked to the draughtsman standing by me—he made no comment, but I could imagine the general attitude that he took—that a draughtsman called upon to make such lettering might well refuse to do so, for if the ordinary map-user were given a map with such lettering, without of course any mention of the excellent reasons Professor Fawcett has put forward, the draughtsman or publisher of the map would have to bear the blame for this, in part at least, extremely ugly alphabet. I cannot but emphasize the ugliness.

I understand that the reason for devising this alphabet with its novelties and its lack of symmetry is that people shall be able to use torn, dirty, and defaced maps with impunity. It seems to me that the way out of that difficulty is not necessarily to design a new alphabet, but since the maps in question are not old maps (for it is clear the alphabet cannot be put on to old maps which might well be torn, dirty, or defaced) it would be better to supply sufficient copies of maps to enable students and others to use them in a clean and undefaced condition.

Mr. MICHAEL SPENDER: Professor Taylor's bold criticisms have made the task of a following speaker a great deal easier. The ugliness of the suggested alphabet seems to me to be an illustration of over-specialization. Of all the possible uses of a map and of all the possible occasions for looking at a map we are asked to suppose a somewhat extraordinary man who takes an old and torn map to the top of a windy hill and then proceeds to read it upside down. At this

rate we shall soon have to be producing maps which can be read on the offset cylinder. A map is a means of conveying a great deal of information, and there is no reason why in considering the presentation of that information the normal conditions of the office or the study should not be presupposed. No one would of course disagree with the basic idea that lettering on a map must above all things be legible, but it seems to me that Professor Fawcett in his over-specialization has contradicted himself in his efforts to achieve maximum legibility. Clearly the main essential in legibility is the differentiation of individual letters. But why, if the maximum differentiation is being sought, should the major possibilities of differentiation be discarded completely? The subtle differences of thickness of stroke and the careful use of serifs serve to differentiate letters, and these when carefully used form what we are accustomed to call style in lettering. Professor Fawcett discards these ordinary devices and leaves us with nothing but asymmetry, which is likely to be ugly.

Although the alphabet certainly goes far to solve a self-set puzzle, it does not solve the general problem as well as if other considerations were allowed to play their part, and other means of delineating letters employed. After all the engineer who had to design lettering which could be punched in metal and then read upside down underneath a grimy machine clearly could not use the variations of stroke which the pen so readily gives on the fair drawn sheet and the lithographic metal so excellently reproduces on the printed map. These technical resources cannot be discarded when designing lettering. In fact a full discussion of lettering on maps must include many factors which have not been mentioned this afternoon. For instance, there is the economic factor of the drawing office; the technical factor of the printing process; and finally, and almost the most important, the pleasure which the map-user is going to experience on seeing the map's presentation of all the information which it contains welded into one general unit.

Mr. H. J. ANDREWS: I am interested in this discussion because I am one of the individuals whose work entails the drawing of lettering upon maps; and by this I mean the finished product which is ultimately reproduced.

As a practical man I have been impressed by the number of elegant types of fairly recent origin which could be used with advantage for the lettering of maps. For example, there is available Gill, which is a sanserif lettering and has been used extensively by the London Passenger Transport Board. It has been recently reproduced on the Green Line maps. If a serif type of letter is wanted there is the comparatively new *Times* fount, which gives a beautiful letter. If differentiation is required so far as political and physical features are concerned, perhaps a combination of the two could be considered. The type should be written out systematically and set up and proved by the practical typographer. This ensures that it shall look as clean and sharp as possible.

I am not in favour of stamping devices. They stamp into the paper and the type is not very sharp from the point of view of reproduction. By the intelligent use of scissors, or preferably a sharp pen-knife, names can be curved as required. One can cut the type half-way up and open it out fanshape either at the top or bottom, whichever is desired. It is also possible to have a double curve. Thirty to forty names an hour can be put down by this method. The speed depends upon the sequence in which the names have been written out for the typographer. An advantage of this method is that it allows the lettering to be done after the topographical details have been inked in. When lettering is done by hand it is usual for it to be put on to the drawing first. Type is constant and does not permit of personal idiosyncrasies creeping into the work.

I take it that in this discussion on lettering on maps the economic and time

factors do not arise. Nevertheless, as lettering takes up a large proportion of the total time necessary for the execution of fair drawings, one would not expect the best lettering on provisional or commercial products, especially when cheap editions are published. It is not possible to give lettering the first consideration when a publication has to be got out at a specific price. It should be borne in mind that block or Egyptian lettering can be executed in one stroke by the use of a suitable pen. It is therefore speedy; it is also legible and probably most suitable for military maps.

I must confess that the alphabet shown on the screen left an unfavourable impression on my mind. It seems to me to be asking too much to expect the draughtsman to draw those awkward C's, G's, and D's with uniformity.

Mr. A. J. WILMOTT: As a map-user, I think that it would be better to reserve serifs for the larger letters and use sanserif lettering in small print. This would avoid covering so much space. In my experience the disappearance of the letters from maps occurs at the folds, and then I find that not only half a letter disappears but usually the whole. Whether or not a new form is beautiful depends much on habit. I cannot object to the use of the Greek ϵ; it is used by many nowadays. At the same time, I should like to have seen some words in which the oblique C's and G's were mixed with some of the upright capitals: this would, I think, look ugly.

Mr. A. R. HINKS: I have naturally studied with much interest the suggestions put forward by Professor Fawcett. I do not wholeheartedly agree with him, for he seems to be thinking rather in terms of the poster than the map. The distinctions he has made might be visible so long as the letters are kept large, but the problem that normally confronts the map-maker is that of getting a great number of names on to the map and ensuring that they occupy as small a space as possible consistent with legibility, so that they shall not interfere with the content of the map.

The letters that Professor Fawcett has designed would be troublesome to draw because he makes such great use of small distinctions of angle and distortions of shape. They are visible when seen on a large scale upon a screen, but if they were reduced to the smaller size of writing upon a map, even if successfully drawn and reproduced, one would not be able to see the distinctions.

A map was published in the *Journal* for August 1939, showing the small island of Jan Mayen. It has relatively unimportant names all over it and a great deal of sharply graduated topographical detail. That map exhibits very well the merits of the style of italic writing with the quill that has been developed in our Society: clearly legible in small sizes even when mixed up with topographical detail. Upon that Major-General MacLeod and I differ. I would point out to him that the kind of letter he has asked for, the hairline upright Roman which was Class VI in the alphabet designed by the International Map Committee which met at Paris in 1913, has in practice been almost dropped. It is clear enough if drawn rather large and in open country, but not, I think, so good as our italic when mixed with detail.

Then there is the economic question. Professor Fawcett did not say anything as to how fast the poor draughtsman could draw those difficult letters that he has designed. The whole point of our written alphabet is that our draughtsmen can write about six or seven times as many names as an older fashioned draughtsman can draw: an increasingly important factor in favour of quill-pen writing, and of doing away with the great number of different alphabets which Professor Fawcett considers it so admirable to preserve.[1] If there are to be fifteen different

[1] See discussion following "Lettering on maps," by Captain J. G. Withycombe (*Geogr. J.* 73 (1929) 429–46).

styles of lettering upon maps they must be drawn, not written, and I assure him that that is an easy way to bankruptcy: unless you are a Department of State.

And now let me refer to Professor Fawcett's numerals. All who have to use numerals very much in calculation agree that the old-style numerals with the ascending 6 and 8 and descending 3, 5, 7, and 9 are immeasurably superior to the modern ones which are all exactly the same height. That is so well accepted now that I cannot understand why many map draughtsmen persist in using the modern numeral in which there is no ascender or descender, and in particular why Professor Fawcett, the reformer, has pinned his faith to the numerals of uniform height which have to be drawn at least twice as big, and occupy more than twice as much space upon the map, to be legible at all. May I refer him to the Antarctic map in the *Journal* for September 1939 as an example of our very small numerals easy to read.

Mr. Andrews spoke of Gill sanserif lettering as used by the London Passenger Transport Board. But Mr. Edward Johnston designed that alphabet for the L.P.T.B. and his design is, in the opinion of many of us, much superior to Gill's. There is a tendency to assume that Mr. Eric Gill is the fount of all good lettering. Quite recently some one who justly admired the stones outside our hall on which the names Kensington Gore and Exhibition Road are cut told a member of our own staff that they were designed by Gill, whereas in fact they were by one of the Society's younger draughtsmen.

Professor FAWCETT: I did not expect much agreement, but there is more than I anticipated. I should like to stress that in reading new types I have usually found that my first impression was that they were ugly. I have analysed that and sometimes come to the conclusion that I was justified, and sometimes not. The average reaction of most human beings to something different from the form to which they are accustomed is that it is ugly. I should like to know what would be the reaction of those who had looked on this lettering a number of times. I am aware that the first reaction is usually the one mentioned, and I agree that beauty, in some respects, depends largely upon custom and habit. I am not suggesting that my design is beautiful. I have set out with the object of maximizing differentiation.

The introduction of an e which derives from the Greek is something to which I have become accustomed in the correspondence of my friends. Possibly for that reason it has entirely ceased, if it ever did, to shock me. I do not see why it should be a shock to see a Greek ϵ. We have mixed Roman and Greek in so many parts of lettering.

I am not a designer; I set out to secure the maximum differentiation between letters of similar form, and this alphabet is the result. Possibly because I have seen it since last May on many occasions and stood back and studied it, it does not strike me now as being so new and abrupt and ugly as those who have seen it for the first time seem to think. It is not a finished design; it is an attempt to get down to minimum factors, to strip the alphabet down to essentials. I hoped that we should discuss rather the principles I tried to state than this first attempt at applying them, but it has evoked an interesting discussion and I thank you for having made that possible.

The CHAIRMAN: I have no technical knowledge of the subject, but I can agree with what Professor Fawcett has said about a new thing being considered ugly; that is a general tendency. I do not think it implies any low standard of beauty when such an alphabet is shown; after all, what we need in maps is legibility, and that apparently is what Professor Fawcett is aiming at. His suggestions have led to a most interesting discussion, and I ask you now to thank him for introducing the subject.

THE CORAL CAYS OF JAMAICA

J. A. STEERS

IN July 1939 an expedition, organized by Dr. V. J. Chapman, of Gonville and Caius College, Cambridge, left for Jamaica to study certain aspects of the flora and fauna of that island and the physiography of its surrounding sand cays. I undertook this last and, by the generosity of this Society, was able to take with me Mr. J. A. Lofthouse, of St. Catharine's College, as surveyor. This paper was written while waiting for a ship home and during the voyage, having been compiled immediately after the outbreak of war, while the material was fresh in mind and could be put on record as soon as possible; it represents only a part of our work. I would like to thank all members of the expedition who helped me, but especially Mr. J. Colman, whose knowledge of coral reefs in Australia and Florida is extensive. The field work was carried out during a cruise of four weeks in the schooner *J. E. Taylor*, of George Town, Cayman Islands, under the command of Captain Theophilus Ritch, who, with his crew, gave invaluable help in all ways.

Sand cays

They are common on coral reefs and partly submerged shoals, round Jamaica as elsewhere. A typical cay is a flattish rounded heap of sand or coarse material eroded from the reef or shoal and thrown up by waves. In addition to coral and shell fragments, the calcareous algae, especially *Halimeda*, play a very important part in the formation of the Jamaican cays, which may occur on any part of a reef and not only on the lee side as on the Great Barrier Reefs of Australia. Salt and Pigeon Islands approximate to the Low Wooded Islands of Queensland. On the cays close to Jamaica no semblance of "promenades" was seen, but on the Morant Cays they were conspicuous and are discussed fully below.

The cays described in this paper fall naturally into three groups: (1) those in Portland Bight, which are typical sand and shingle formations on a windward shore; (2) those in Montego Bay, which is sheltered from the prevailing winds: mainly mangrove islands with relatively small cays; and (3) the Morant Cays, about 60 miles south-east of Kingston: the only examples we found of ordinary sand cays fringed to windward by well-developed promenades. Once a cay has formed plants will soon take root, and all stages from a cay with a few creeping plants to those with thick woodland were seen. Except upon some islands in Portland Bight and Montego Bay mangroves are not conspicuous on the cays described in this paper.

Beach-rock

On tropical beaches the sands, or even coarse shingle, are commonly cemented into a hard rock, called beach-rock or conglomerate,[1] by carbonate

[1] For a discussion on the origin of beach-rock, see R. A. Daly, Publication No. 340, Carnegie Institute of Washington. This paper refers mainly to American Samoa, but references are given to other works.

of lime precipitated from sea-water. Round Jamaica the vertical range of this rock on the cays examined was seldom more than about 3 feet, and usually less. No comprehensive theory has yet explained the formation of beach-rock and none will be attempted here; but I would call attention to its distribution. First, it always occurred in the zone of wave action on a beach and dipped at the slope of the beach. It might be on the windward side of one island and the lee of the next; never did it entirely surround an island. Very often several zones or lines of the rock were seen, and were always carefully mapped. It clearly forms along an actual beach, but the beach may later be washed away from within it, which accounts for off-shore lines of rock. The sand of a cay may move and cover up part or all of earlier formed belts: the rock often runs into and under a cay. As cays are unstable structures, much modified or even completely obliterated by storms and hurricanes, it can be understood how these irregularities are produced; careful mapping of beach-rock zones will explain part at least of the evolution of a cay, as will be apparent from the maps and descriptions of individual islands, and from the discussion below of the Portland Bight cays.

The cays in Portland Bight

Barebush Cay: a small cay, rather high for its size. The island portion is insignificant, but the amount of beach-rock implies former stages when the cay was considerably larger. The beach-rock always shows a normal outward dip, and the outermost zone on the eastward side is about 1 foot lower than the other lines. The cay is covered with grass, creeping plants, and some low shrubs. There is a fair amount of coral round it, and the cay itself is situated towards the north and windward end of the reef. The cay sand is largely *Halimeda*, with coral and shell fragments.

Little Half Moon Cay: a regularly shaped island, well forested, and reminiscent of some of the Capricorn and Bunker Islands.[1] It is almost entirely built of sand, mainly *Halimeda* with coral and shell fragments. At the time of our visit, there was but a narrow beach all round the island, and at the back of the beach was a low sand cliff. On the north-western side was a slight development of beach-rock, some of which was actually forming. The cay stands on a small reef, which to north-east is partly fringed by boulders inside which at least two mangrove seedlings had rooted. As in all the other islands, the lower, unforested parts were frequently covered with *Sesuvium*.

Big Half Moon Cay: a large and picturesque cay, regular in shape, which has recently suffered a good deal of erosion, many trees especially on its sheltered side being undercut and lying on the beach. There is a good development of normal beach-rock on the western side. On the weather side of the reef on which it stands is a small boulder zone. The vegetation closely resembled that of Little Half Moon Cay both in details and general appearance. The sand of which it is made is also similar, but piled up rather higher, to about 10 feet.

[1] The chief references to the Australian Reefs are: *Geogr. J.* 74 (1929) 232–57, 341–70 and 89 (1937) 1–28, 119–46; also M. Spender, *Geogr. J.* 76 (1930) 193–214, 273–97; and *Reps. of the Great Barrier Reef Expedition* 1928–29 (Brit. Mus., Nat. Hist.), vol. 3, No. 2, 1931.

The Portland Cays

(a) *The Middle Portland Cay:* the largest of the three, well covered with bushes, shrubs, creeping plants, and grasses. It is another pure sand cay, *Halimeda* playing a large part, especially on its lee side. The sand on the windward side was much finer. Beach-rock is almost entirely confined to the lee side of the cay. Some of this rock is arranged in echelon strips suggestive of a gradual growth of the island to the north-east. The outer line of beach-rock is about 6 inches lower than the inner line. The reef is relatively rich in coral growth.

(b) *The Southern Portland Cay* is an insignificant sandbank with *Sesuvium* and low bushes growing on it. The bank, which is undergoing erosion, was formerly much larger, as is indicated by the considerable development of beach-rock on its windward side (contrast the Middle Cay). There are four parallel outcrops of this rock in some places. The cay is formed entirely of sand, *Halimeda* being abundant.

(c) *The Northern Portland Cay*, which is nearly circular, was a good deal undercut on its weather side. Although small, it carries trees up to 25 feet high. It stands on a small reef. There is a fair amount of beach-rock, mainly on the lee side. The arrangement of the zones in this rock suggests a former small and blunt spit running north-westwards from the western end of the cay.

The Pelican Islands: two cays on the eastern side of Portland Bight, the larger being the most attractive island we visited. It is made entirely of sand, and rises to 10 or 12 feet in its highest parts. The southern end and much of the inner part are grass or *Sesuvium* covered, and the higher plants and trees seem to have been kept in check to some extent. The larger and older trees are nearly all at the northern end, where there is also a well-developed example of *Avicennia*. Near the southern end of the windward side at least four seedlings of *Rhizophora* have taken root on the reef near the cay. The presence of both these species of mangrove on the same pure sand cay type of island is interesting. Beach-rock is confined to the lee side of the island; it has the usual seaward dip, and is often in three or more nearly parallel belts. The cay stands near the weather side of the reef, but there was no development of the boulder zone. The sand of which the cay is made resembles that described for other examples.

The smaller Pelican Cay is a simple sand island whose vegetation is generally similar to other comparable islands. The beach-rock zones on the south-western side are prominent; here again the outermost zone is the lowest by a few inches. The cay stands on a small reef separate from that on which its bigger neighbour rests.

Pigeon Island. Pigeon Island and Salt Island are two structures very different from those already described in Portland Bight. They are primarily mangrove islands, and although unlike one another in detail, they bear to the sand cays a relation rather similar to that existing between the Low Wooded (Island Reef) type of island of northern Queensland, and the islands of the Bunker and Capricorn groups at the extreme southern end of the Barrier Reefs.

The shape and general appearance of Pigeon Island are shown in Fig. 1. On all but the sandy and open northern shore mangroves make exploration

difficult. These mangroves are associated with ridges or expanses of coarse coral shingle which forms the true dry land boundary of the island, but they frequently grow seawards of it. On the eastern and southern sides the shingle widens out into broad tracts, in part covered by dry-land shrubs. The northern side of the island consists of a wide sand area, and towards the westward point there is a densely wooded strip passing into mangrove. The shingle is coarse on the surface, but in places passes into finer material below. The surface weathers to a blackish colour. Large patches of sand also occur in the shingle areas. Within the shingle and sand is an extensive lagoon of dark brown water (salinity 35–36 per cent.), connected with evaporating

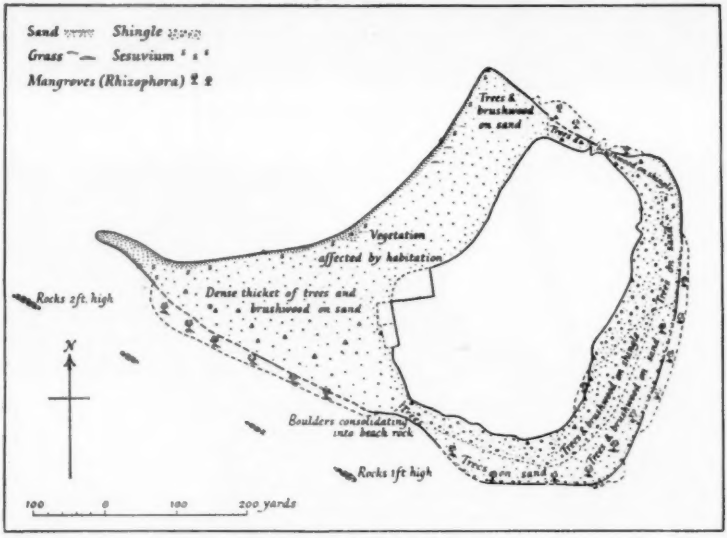


Fig. 1. Pigeon Island

tanks for a local salt industry. The boulder zone is, at its lowest level, occasionally lithified, but there is no true beach-rock nor a promenade.

Salt Island. Salt Island resembles Pigeon Island: the differences between them, apart from local details, are probably due to Salt Island being somewhat more sheltered.

The "island" part of Salt Island, whether shingle or sand, is small (Fig. 2). Along the eastern side there is a fairly continuous strip, often very narrow, of shingle ridge. In one or two places it widens and carries a land flora. But all along this side the shingle falls quickly into mangrove swamp. At the south-eastern corner, near the Beacon, there are patches of sand, and sand (mainly *Halimeda*) runs westward into the impenetrable mangrove belt. In this stretch it resembles the Bogue Islands, and it is difficult to say if one is actually on an island or only on a slightly higher patch of sand in the mangroves. On the edge of the reef near the Beacon there are one or two small and discontinuous patches of boulders.

Westward from the Light (north-eastern corner) the rather coarse shingle of the windward side gives place to stagshorn shingle, but farther on this lessens and the quantity of sand increases, but not regularly. However, from the Light to approximately the north-western cape it forms a unit in some

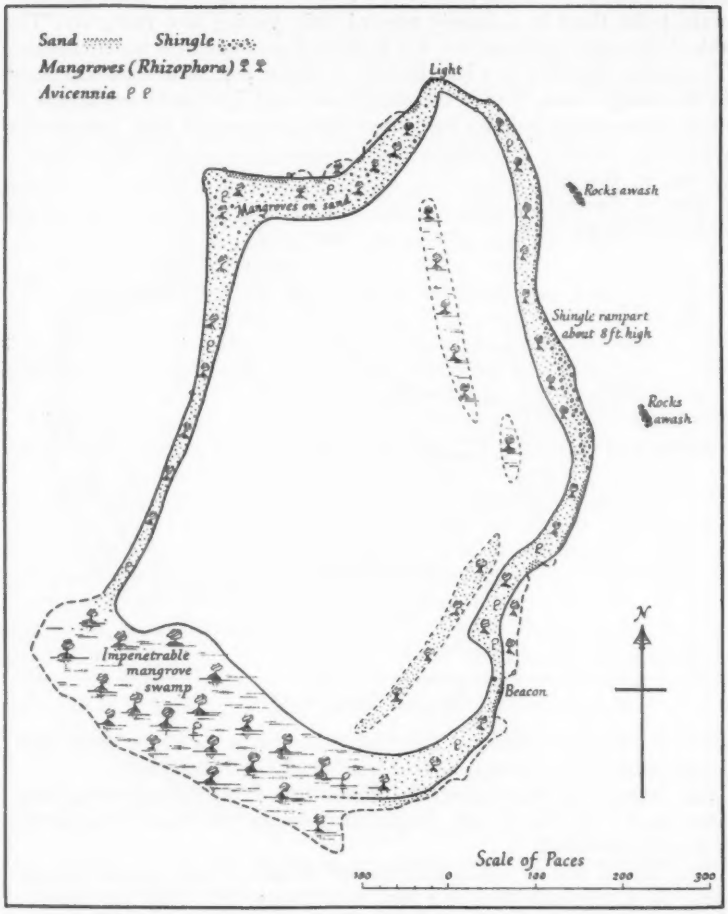


Fig. 2. Salt Island

ways resembling a cay, and roughly comparable to the sandy area on Pigeon Island. Most of the western side, and especially the south-western part of the complex, is thick mangrove swamp with occasional patches of sand, some of which are just high enough to be classed as immature islets.

There is no trace of beach-rock nor of promenade on the island. In the inner parts there are large clumps of mangrove rising out of the lagoon.

Vegetation on Little Half Moon Cay

Steep beach on Big Half Moon Cay

D. J. Crisp

Beach-rock

The weather side of Salt Island

The interior of Salt Island

There are also two areas (near the Light and near the Beacon) of dead mangroves, presumably telling of a former hurricane.

Discussion of the Portland Bight cays

We have now described all the islands investigated in Portland Bight. Apart from Goat Island, a severed part of the mainland, a certain number of small islands consisting mainly of mangroves (*e.g.* Careening Island [1]) were not visited. The islands already described fall into two groups: Salt and Pigeon Islands and the true cays.

A glance at the map (following p. 80) will show that the cays are all at the outer side of the Bight and stand on individual reefs whose windward sides are but slightly sheltered: they are in an environment resembling that of the Bunker and Capricorn Islands (*loc. cit.*). The 100-fathom line is some 6–10 miles seaward of them and the reefs on which they stand rise from depths of 18–10 fathoms. The cays are built of material of organic origin. There seems to be no particular relation of cay to reef; some are to windward, others to leeward.

The most interesting physiographical features on the cays are those associated with the beach-rock, of which there are often several zones round an island. As the tidal range in Jamaican waters is usually under a foot, and always less than 18 inches, the vertical range of beach-rock is correspondingly small and possibly limited to the zone of well-aerated water, or approximately to the zone of wave action on a beach. The presence of vegetation, and so of various acids, may or may not help in its formation; there were however no completely unvegetated islands.[2] Once formed, it is a relatively stable material, judging by the amount seen round many of the smaller islands. Hence, I suggest that the former shapes of cays can often be estimated by the beach-rock zones round them.

How deep with respect to mean sea-level beach-rock can form is uncertain. From observation in these waters, I am inclined to think a foot or two at most, but it may be a little more; hence, if outer beach-rock zones are sometimes lower than inner ones, the difference is probably insignificant if not more than, say, a foot. If, on the other hand, the difference in level is considerable, vertical movement of some sort seems likely, and as Jamaica is in a seismic area, it is certainly possible that earthquakes have affected the cays.

The cays are naturally unstable structures. Reversal of ordinary wind conditions will change them considerably; a hurricane will, or can, destroy them. Therefore it is probable that the changes denoted by several zones of beach-rock testify to strong winds or hurricanes.

Pigeon Island is relatively exposed and lies at the head of a major break in the reefs to the south-west and north-east of the seaward side of Portland Bight. Barebush and Pelican Reefs give it some shelter, but it is not in quite the same environment as the sand cays. Salt Island stands about 5 miles farther back, and is more sheltered. Wave action nevertheless has produced

[1] Dr. Chapman, who visited this island independently, tells me that there is a low sandy area in it; it appears to be very similar to the Bogue Islands. Its position at the head of Portland Bight is consistent with this description.

[2] This is mentioned because in Australia beach-rock is limited to cays with vegetation

a great deal of coarse shingle on both, especially on Pigeon Island. I do not see a simple explanation of the fact that the sand cays are in a more exposed area than the shingle islands, but a comparison with the Queensland reefs may help. There the sand cay type of island is sometimes in more exposed places than the Low Wooded type. Yet the latter demonstrate shingle phenomena. This is partly explained by the stagshorn shingle in Queensland, where it was common in the normally sheltered waters within the outer reefs; hence its abundance on Salt Island is possibly significant. On Pigeon Island it was not conspicuous. The small, almost insignificant, tidal range is probably vitally important in the formation, and especially in the location, of the cays. If the range were greater, I doubt if cays would be able to form in such an environment as the outer parts of Portland Bight. The greater range of the tide, and consequent greater wave action at high water, would tend to sweep away the sand, especially when so much of the sand on all the islands is *Halimeda*, which sinks slowly in water and is very flaky.

There is comparatively little coral growth on most of the Jamaican reefs, at any rate as compared with the Queensland reefs, and this limits the supply of shingle to the cays. Judging by the much larger amounts of coral shingle on Pigeon and Salt Islands,[1] there seems to be a richer growth in these sheltered localities. The contrast between the compositions of the cays and of Pigeon and Salt Islands may then be due to the relative amounts of coral growth in the two environments. Presumably storms and strong winds are responsible for throwing up the shingle, and the increase of shingle on both these islands may indicate quieter normal conditions but greater destruction in storms of comparatively easily broken coral. More underwater work is necessary before this point is resolved, especially if the whole of Portland Bight is considered in relation to the Port Royal cays.

On several reefs on which cays have been built in Portland Bight, the waves have made a small outer boulder zone on the weather side, inside which mangroves have begun to take root. As the reefs are comparatively close to the mainland, there is little significance in this, because mangroves grow in any favourable locality. Whether they will spread and make a complete screen time alone will show.

The Bogue Islands, Montego Bay

The only reference I have found to the structure of these islands is in Hill's work on Jamaica.[2] He states that there are eight islands, using the term loosely, as he says that several show no land at all; they are, in fact, clumps of mangroves. The group lies in enclosed water, and time and circumstances limited us to a detailed investigation of the two most seaward and largest mangrove areas. On the inner of these two no land is seen; on the outer at least five islets exist. These are all low sand areas lying on or near the outside of the mangroves.

The first, taking the islands in order from east to west, is conspicuous for

[1] It is perhaps significant that Pigeon and Salt Islands are nearly as big as their reefs. This is not the case with the cays. Relatively deep water is close to, and on all sides of, Salt and Pigeon Islands.

[2] R. T. Hill, in *Bull. Mus. Comp. Zool.*, Harvard, 34 (1899) 89.

The easternmost of the Bogue Islands

North-East Cay, Morant Cays

The promenade, North-East Cay

Depression in the promenade, Middle Cay, Morant Cays

its eight coconut palms, its sole claim to distinction. Like the others, it is a long (*c.* 130 yards) narrow bank of sand composed of shell and coral fragments and abundant *Halimeda*. Its maximum height is about 18 inches near its seaward edge, and it slopes back gradually into mangrove swamp behind. The second islet is smaller and nearly surrounded by mangroves. The third is about 250 yards long, but is hardly dry land throughout this distance: its width varies from a few yards to twenty or more, but at its south-western extremity it widens out into a true cay, measuring about 50 yards by 20 yards. A deep indentation in the outer line of mangroves separates this from the two former islets and may be the site of a former passage. The fourth islet, which possesses a true beach for about 50 yards, is some 200 yards long, and in places about 40 yards wide. As with the others, its surface sometimes drops to swamp level and, except for the beach, is enclosed by mangroves. The fifth islet, at the western extremity of the outer mangroves and differing from the others in being formed of fairly coarse shingle, is in two parts separated by a swampy patch, with a total length of about 160 yards.

Apart from the five islets there are also stretches of sand occasionally to be seen between them. In essence they are precisely similar, though they do not rise high enough to merit the description of islet. All these features are on the outer side of the mangrove swamp. The lee side shows no land at all, the water being 4 or 5 feet deep immediately outside the trees. There was no land of any kind visible in the next (inner) mangrove mass. We were unable to visit the smaller areas close to the coast: seen from a height one or two of these appear to be annular groups of mangroves enclosing a lagoon.

The outer five islets, all combined in one large mangrove area, form a simple unit, and can be related to the other cays described in this paper. Montego Bay is sheltered from the prevalent trade winds, and occasional winds from a northerly or north-westerly direction are responsible for the waves which have built up these low sand islands. The only shingle is found at the western end, which is the most exposed part. The whole complex lies within a coral reef zone, and the origin of the islets is similar to those in Portland Bight or Port Royal, allowance being made for great differences in environment and exposure. Mangroves have spread far more than elsewhere and dominate the landscape; the interior of the main outer mass of mangroves is composed of young trees about 5 feet high which constitute a relatively new growth and now mask what was probably an annular island.

Hill referred to the Bogues as pseudo-atolls, and gave a diagram indicating a ring of sand enclosing a shallow lagoon. This description will not apply to the two large outer mangrove areas, for there is only a discontinuous line of sand along the outer side of the outer mangrove mass, and no land at all round any of the next inner mass. I am unfortunately unable to say how far the smaller and inside islands now conform with Hill's view. It is clear that since his visit the mangroves have spread widely, and his eight islands cannot be identified with certainty. One at least appears to be now incorporated in the mainland mangroves, and several smaller mangrove clumps have grown up, forming new islands.

The Morant Cays

The four Morant Cays are situated on an arc-shaped shoal some 60 miles south-east of Kingston, the convex side of the shoal facing south-east. The shoal is part of a large bank on which depths of 18 or 20 fathoms occur; on the shoal the depths are usually less than 5 fathoms and just round the cays soundings show about 2 fathoms. Both bank and shoal afford some protection from the south-east winds, and heavy seas break on the outer edge of the shoal where depths of the order of 4 fathoms are found close to the cays. Three of these cays were carefully mapped and investigated. It was impossible to land on the fourth, Rocky Cay. The shoal is one of the numerous submerged or partly submerged features of the Caribbean whose origin has been discussed elsewhere [1]: it rises from depths of 600 or 700 fathoms. It is however important to note that the islands are far from being true coral cays. Living coral round them occurs in individual colonies which show no signs of fusing to form a reef, but appear to be themselves healthy.

North-East Cay. At the time of our visit this was in three parts, the main cay and two small detached shingle islets at its northern end. These two were *Sesuvium*-covered, and separated from one another and from the main cay by channels about 3 feet deep. At times they are joined together (see *West Indies Pilot*, 111 ed., 1933). All these islands have been built by wave action, and consist of coral fragments, shells, shell sand, and a great deal of *Halimeda* sand. Inside the main island there are two or three depressions in which the water-table rises. On 3 August 1939 the water-table in these hollows was slightly below high-water mark on the beach. The water is brackish to salt.

Nearly the whole cay is covered with creeping plants and grasses, the more important genera being *Sesuvium*, *Ipomoea*, a grass, *Portulacca* (?), *Tribulus*, and two planted coconuts. In general *Sesuvium* usually flourished at slightly lower levels than the grass.

Along the weather side of the cay, there is a good development of beach-rock closely resembling the promenades of the Low Wooded Islands of Queensland. Apart from this feature, normal beach-rock with dips conforming to the slope of the beach was seen at the southern end of the cay, and extended some distance beyond it. A remark in the *Pilot*, strictly applying to South-East Cay, is nevertheless pertinent: ". . . sand spits extend from the end of this cay and alter in shape with the seasons of the year; in summer, the south-western spit is washed away and the sand composing it is deposited on the western side of the cay." Our own investigations agreed with this and also that it applied to each of the cays. It is important to note that the surface of this ordinary beach-rock was about 1 foot lower than that referred to as the promenade, and was just below high-water mark; it was estimated to extend to approximately 18 inches below mean sea-level. The only other feature of this cay worthy of note was on the weather side, where the sand was piled up into a grass-covered ridge from 4 to 5 feet high, and fronted by a lower sand platform which fell directly to the beach. (The cay had maximum length in an east-north-east line

[1] See *e.g.* J. W. Spencer, in *Trans. Canadian Inst.* 5 (1898) 320.

of 470 yards: its greatest breadth, at right-angles to this line, was about 280 yards. It seldom reached more than about 7 feet high, apart from vegetation.)

Middle Cay. The promenade and beach-rock developments are conspicuous and interesting, showing how sand is washed out from behind beach-rock, leaving the curved line seen on the north-eastern side of the cay. The features of the promenade are discussed below. The cay proper is a sandy structure similar to North-East Cay, the northern part consisting of almost bare sand showing signs of recent growth.

South-East Cay. This cay is irregular in shape, with an extensive sandy area (about 530 yards east to west, and 430 yards north to south, including the promenade) joined to the promenade by a narrow neck. Beach-rock immediately in contact with the cay is normal and is found on its western, northern, and eastern [1] sides. Along the northern shore in particular, there are at least three belts of this rock at very different levels, the outermost being the lowest. As these outer belts are well below water-level, it was not easy to examine them, especially as a swell was running. They appear however to be formed of the same rock as that now fringing the beach, and all have a northward dip. The outermost zone varies from 6 to 10 feet or more below the surface. If beach-rock can only form along actual beaches, and within fairly circumscribed vertical limits, it seems that on this cay we have evidence of a tilting downwards to the north in at least two stages. This is also partly borne out by the fact that the promenade shows signs of a similar tilt.

The Morant sand cays, together with their vegetation [2] and lines of ordinary beach-rock, except for the suggested tilt mentioned above, do not present any serious problems. They are wave-formed features and rest on the highest part of the shoal. Their shape will vary in part with that of their foundation, and also with the incidence of wind and weather. Once beach-rock is formed relative stabilization is obtained, although sand can be washed out from behind the rock and leave it off-shore. Promenades however present a more difficult problem, and one that at present cannot be fully solved.

The following are the essential points concerning the Morant promenades:

They occur on the windward side of the cays. They are mainly composed of cemented sand and, in hand specimens, are of the same nature as ordinary beach-rock; they may contain shells and coral fragments. Their outer and upper surfaces are eroded into very jagged forms. Apart from the detailed erosion forms, the average surface is often remarkably level, and from about 12 to 18 inches above high-water mark; it is this characteristic which makes the term "promenade" applicable. On the seaward side there are frequent lower platforms (1 or 2 feet below the top surface) of the same material. They are often algae-covered, but do not show the same erosion features as the higher levels. The upper exposed surface weathers to a dark brown or black colour. In places, especially on Middle Cay, large depressions in the promenade were often floored with salt intermixed with algae. The outer surface layer of the

[1] Along this side the rock is well off-shore, but at normal level.

[2] The vegetation of the three islands visited is very similar, and all are the resort of countless sooty terns and noddies.

promenade, about a quarter to half an inch in thickness, was usually hard and compact, and stalagmitic in appearance when broken. Its top surface was often a dark purple in colour, and in detail somewhat resembled clinker in appearance. It seemed possible that this top layer may in part be due to a process similar to that now going on in the depressions where salt and algae appear to be producing a hard crust. Specimens of this crust and hard outer layer were taken, but their complete analysis will have to wait indefinitely. *Sesuvium* and grass were frequently found on the top surface, especially at or near its inner edge; the presence of grass suggests that it is not often inundated, though it must often be spray-covered. On South-East Cay the inner part of the promenade, including its hard outer cover, was below water-level in a sheltered area on the south-west-facing side of the island. The whole of this promenade was studied in detail and the conclusion reached that this part of the promenade had probably been warped down by a tilting movement and so brought into possible accordance with the deep-lying beach-rock mentioned earlier. The promenade on South-East Cay is on the edge of the shoal, and immediately in front and also below it is the actual rock of which the underlying mass is made. It was difficult to approach this rock, but specimens indicated that it was a crystalline limestone quite unlike the promenade rock itself; it was riddled with *Lithotrya*, which was absent from the promenade. The promenade rock often shows clear dips, but they are not regular in direction. The promenades occasionally show long and fairly straight cracks or joints, not in any particular arrangement, but on a considerable scale. No similar formation was seen on any other island visited.

Does this promenade indicate a raised feature? It has been argued elsewhere that the promenades on the Low Wooded Islands of Queensland imply a slight fall of sea-level. At first sight, the Morant promenades are so similar that a like view is suggested, especially as they are definitely rather higher than normal beach-rock formations on the same islands. The fact that they are often grass-covered favours this view, as does the nature of some of the surface erosion which appears to be due to atmospheric weathering. I am not however convinced that uplift has occurred. The three promenades visited are not sufficient evidence on which to base a major decision, especially as there are no corresponding features on the inner cays. They are also in very exposed places and would certainly be awash in storms. Their frequent evidence of dip almost suggests a building of layer upon layer. They are formed of lithified sands with some shingle, and in exposed places, such as the weather side of Morant Cays, it is reasonable to suppose that this lithification would extend through a greater vertical range than, say, in Port Royal or Portland Bight. It is however difficult to account for the general horizontality of these promenades. For the moment I prefer to call attention to the facts and leave their interpretation until more are examined; other examples may be found on the Pedro Cays. As there is relatively little shingle in their formation and as their environment is so totally different, I feel that any close comparison with the Australian promenades is unwarranted, inasmuch as these features are really the only points of resemblance between Morant Cays and the Low Wooded Islands of Queensland.

Conclusions

The outer cays in Portland Bight are all sand formations. They are all vegetated: one or two are covered only with grasses and creeping plants, others carry relatively dense woodland. Their most interesting features are the beach-rock formations round them.

Pigeon and Salt Islands, also in Portland Bight, are shingle and mangrove islands and very different from the sand cays. They are also, especially Salt Island, situated in more sheltered water. No complete reason can be given for the fact that these more enclosed islands are formed of coarser material than the exposed cays, but it is possible that the almost negligible tidal range, and perhaps a greater abundance of more easily destructible coral in these more sheltered waters, play a dominant part in this distinction.

The Bogue Islands are primarily mangrove swamps, with a discontinuous rim of sand on the exposed side of the outer mass. Allowing for their sheltered situation, they appear to fall in with the general evolution of the whole of the Jamaican cays.

The Morant Cays, although simple sand formations, are quite distinct from those near the mainland of Jamaica: they are built on the highest part of a submerged mass. They are unique, amongst all the islands investigated, in possessing promenades.

Individual coral colonies on most of the reefs round Jamaica are fairly abundant, but, though thriving, they tend not to fuse together to form such massive reefs as, for example, those in Queensland.

Halimeda sand is particularly abundant on all the islands examined, and in many cases forms a large proportion of the material of which they are built.

The mapping of beach-rock has received particular care, and although no further theory has been put forward to explain its origin, it is suggested that its limited vertical range in places where it was known to be forming, or had but recently formed, implies that it is built usually within the zone of wave action on a cay. If masses are found at depths significantly greater than this it may mean a vertical movement of the cay which it fringes. Several zones of the rock at normal level seem to indicate changes in the form of the cays, probably, but not necessarily always, associated with storms and hurricanes.

APPENDIX: THE SURVEY METHODS EMPLOYED ON THE CAYS

J. A. Lofthouse

With the assistance of two of the schooner's crew, it was possible to develop a method of survey which offers many advantages for this type of work. Fifteen islands were mapped by running round them a closed traverse, measured with a 100-foot chain, and by taking bearings with a tripod prismatic compass. A plane-table was used, and both traverse and detail plotted while on the ground. When dealing with boundaries as indefinite as those met with on sand cays, the use of a detail book entails a risk of loose ends and discrepancies which might not be discovered until too late. In all this work we were limited for time. A further advantage of plotting the map in the field was that with increasing practice it became possible to sketch in most of the detail accurately without pacing many offsets.

Statistics of this method collected for the fifteen cays on which it was employed yielded the following mean averages:

Length of closed traverse when plotted	15·9 inches
No. of stations	8
Closing error	0·05 inches
Time for completed field map	$2^{1}/_{4}$ hours

This time average often included two or three "legs" taken off the main traverse. This method is greatly superior to that of a hand compass and pacing sketch, while the time taken is little longer; it is more than sufficient for the production of a physiographical sketch of such changeable formations. It was possible to rely on the compass used to within a fraction of a degree.

Triangulation was impossible, as most of the cays were covered with brushwood or trees. In any case nearly all the features of interest were near the water's edge, and this made a traverse the best method: the random nature of the very small inaccuracies met with is reflected in the negligible closing errors, which never exceeded one-tenth of an inch and were often nil. A scale of 100 feet to an inch was employed on all but three islands, whose large size made it necessary to adopt 100 yards to an inch. The tidal range of only a foot removed one difficulty, but was also responsible for the narrow beaches. Overhanging trees and mangroves spreading out beyond the dry land frequently made it necessary to work for long stretches in water knee-deep. The main vegetation boundaries, as well as the nature of the ground, were always shown. The conventional signs used throughout were selected from those employed by the Great Barrier Reefs Expedition of 1936.

Besides the fifteen cays surveyed with this method, certain other maps were made by similar methods modified to suit particular conditions. Three small cays were of such a size and shape that a short series of stations along the main axis was preferable to a closed traverse. Two were so small that they could be sketched from one point. Pigeon Island presented certain difficulties owing to its densely wooded shores. Twenty-nine stations had to be used to complete a traverse of nearly 2000 yards. As the inner lagoon was almost free from mangroves, it would probably have been better to have fixed that by triangulation from a measured base line, had time permitted. Most of the detail could then have been filled in by offsets or short legs from the lagoon. Salt Island could not be mapped by this or any other accurate form of ground survey, but we succeeded in making a hand compass and pacing sketch round three sides of it, nearly all the work being carried out in water 2–3 feet deep. The remainder had to be completed by boat. The position of our schooner, at anchor under the lee of the island and steady in the trade winds, was fixed by bearings taken from the land part of the island. By rowing on a given course and taking back bearings on the schooner, the traverse was closed. A ridge of deep-lying beach-rock off South-East Morant Cay also had to be fixed by taking bearings on a small boat rowed over it.

The remaining maps of the Bogue Islands and the Palisadoes were only a matter of filling in physiographical detail on, and making some revisions to, existing maps and charts.

OXFORD UNIVERSITY GREENLAND EXPEDITION, 1938

J. C. SUGDEN AND P. G. MOTT

THE expedition was one in a series sent out by the Oxford University Exploration Club to explore and carry out scientific investigations in the unknown hinterland between the Søndre Strømfjord and Evigheds Fjord, latitude 66°, West Greenland.

On the 1936 expedition (*Geogr. J.* 90 (1937) 315–34) the discovery was made that the Sukkertoppen Ice-Cap, which covers 900 square miles of the interior between the two fjords, was distinct from the main inland ice. A party of three crossed the Sukkertoppen Ice from north to south, and viewed for the first time the mountains to the north of Evigheds Fjord. The country seen on that journey proved of such exceptional interest that it seemed a suitable ground for general exploration and for glaciological research in the future.

Early in 1938 therefore preparations were begun on a third expedition to this region, with a programme of glaciological and meteorological work much of which was based on the previous investigations carried out by Professor Ahlmann in Norway, North-East Land, Spitsbergen, and Iceland. It was hoped to obtain a complete survey of all the factors governing the behaviour of an inland ice-cap, *i.e.* accumulation, ablation, and "icification" of the firn above the firn line, ablation and rate of outflow of the glaciers descending from the ice-cap. The Sukkertoppen Ice-Cap was a model ice-cap for such research because of its limited size, comparative ease of access, and uniform structure.

The main cost of the expedition was borne by the individual members, but financial assistance was received from the Royal Geographical Society, Oxford University Chest, and several Oxford colleges; while a number of manufacturing firms supplied goods free, or at greatly reduced prices. The Admiralty, the Royal Geographical Society, and Oxford University Survey School all lent instruments. A large number of meteorological instruments as well as the very elaborate wireless equipment came from Germany: the former through the generous offices of the Geophysical Institute of Leipzig, while the latter was lent by Messrs. Telefunken, of Berlin.

The total cost of the expedition was in the region of £800.

The following made up the personnel that sailed from Harwich on 2 July 1938: J. C. G. Sugden (organizer and leader); P. G. Mott (surveyor and co-leader); E. Etienne (physicist and wireless operator); T. H. Kershaw, M. T. C. Sadler (assistant meteorologists); J. H. Radford, J. A. Adderley (assistant surveyors). The original plan was to reach Greenland by the middle of July, but the yacht chartered for the outward journey had to be abandoned at the last moment. After some delay we sailed from The Faroes on a Norwegian fishing-depot ship, and in nine days reached Faeringerhavn, the international harbour of West Greenland. A motor boat took us the remaining 200 miles of the journey up the coast, and on the night of July 31 we anchored in the small harbour of Kangamiut at the entrance of Evigheds Fjord.

Evigheds Fjord is roughly in the shape of a dog's leg. At the head of the

most westerly arm of the fjord two large glaciers lead down from the Sukkertoppen Ice, terminating in high ice-cliffs that calve into the fjord at frequent intervals. Within 100 yards of the southernmost glacier of the two the motor boat finally anchored. On the north shore a perpendicular rock-face rose unbroken for 5000 feet, while on the south side a steep moraine terminated in polished slabs near the water's edge. The only possible landing-place was a small bay a few yards from the seracs of Taterat glacier, and liable to be swamped by a calving wave. As a precaution two lengths of line were attached to the dinghy, one being fastened to the motor boat and the other secured on shore. The dinghy could thus be pulled to and fro without the use of oars. This method succeeded until an unusually large wave upset the boat as it was arriving at the shore end. As a result an automatic meteorological recording instrument was damaged beyond repair; and instead of getting a continuous record of certain factors, we had to fall back on the method of taking series of readings.

For the last mile of its course the Taterat glacier is broken up into a chaos of tremendous seracs and ice-pinnacles, but above this ice-fall it flattens out considerably, and we were able to establish a sledging-base there. It took four days to carry nearly 3 tons of equipment up the 900 feet of moraine to the sledging camp, and the work was impeded by drenching rain during much of this time.

The first trip with the Nansen sledge revealed an unexpected obstacle to our plans, in the shape of a second ice-fall up which there was no hope of finding a route on foot, far less for the sledge. The only way of gaining the upper part of the glacier lay over a steep lateral moraine and down again on the far side. This was a serious set-back since, with the limited time at our disposal, it was important that we should be able to take the sledge the whole way up to the ice-cap. Further reconnaissance showed clearly that the sledge would have to be abandoned beyond this point, but that there was a possible carrying route to the ice-cap over a steep and heavily crevassed tributary glacier on the north side of the main Taterat glacier. The original plan of establishing a meteorological and wireless station at the centre of the Sukkertoppen Ice had therefore to be greatly modified. Instead it was decided to make the main base (Glacier Camp) at the foot of the ice-fall, which constituted the limit of the sledging route. A wide expanse of clear ice, where a tributary glacier joined the main arm of the Taterat glacier, provided an excellent site for the two largest tents that housed the bulk of the meterological and wireless instruments. A smaller, but effective, "firn" station (Igloo Camp) was planned on the edge of the Sukkertoppen Ice at 4500 feet, to which only the lighter and essential instruments would be taken. On the mountain side, 500 feet above Glacier Camp, a flat rock-shelf offered a convenient site for a survey station, with a view over the lower half of the glacier, beyond which the fjord stretched for 30 miles to the sea. Boulder Shelf, as this camp was known, provided an ideal position for studying ice-movements, while the neighbouring hillside contained the only possible bases for the stereo-photographic survey.

Within eight days of landing all three camps were established and in working order. The two meterological stations (Glacier Camp, 1100 feet;

Glacier Camp

The Taterat glacier snout

Mount Atter

Sledging base in Taterat glacier

Igloo Camp, 4500 feet) were equipped with the usual set of thermometers and instruments for recording temperature and humidity. At the lower station there were in addition a rain-gauge, barometer, barograph, actinograph, and two self-recording anemometers at 5 and 15 feet above ground respectively. Whenever conditions were suitable, measurements on the intensity of the sun's radiation, and the radiation balance of the ice and snow surface were carried out at both camps. The geophysical research into the properties of the firn, etc., was done at Igloo Camp. At Boulder Shelf (1600 feet) records of the twenty-four hourly movements of the Taterat glacier were maintained for five weeks.

The complete results have not yet been worked out, but a summary of the findings may be here stated. A complete account of the scientific work of the expedition will be published in due course, and will contain the observed recordings of all instruments in addition to the calculations and resulting conclusions.

Glaciology

Movements of Taterat glacier. Below Boulder Shelf and just above the second ice-fall a series of nine markers were placed at approximately 150-yard intervals across nearly the full width of the glacier. Four of these reference points were marks on morainic boulders, while the rest were artificial markers where the ice was free of any trace of moraine. The artificial markers were constructed from ration boxes with two uprights nailed to the sides and supporting a cross piece from which was suspended a target, painted red, with a weight on the end. The sides of the box afforded some protection to the suspended target, which remained vertical even though the box often tilted badly as a result of melting beneath. In spite of this precaution it was usually necessary to adjust the boxes every five days when they tilted so badly that the suspended weight touched the sides.

Readings were taken at twenty-four hourly intervals on each of three markers every day for five weeks. The results are as unexpected as they are interesting. The variations of flow of any single point from one day to another were found to be often greater than the mean speed of the point over the whole period of five weeks. Thus for instance at the centre of the free ice (where there was no morainic matter) a maximum rate of 3 feet might be reached on one day, while on the next the same point would move only 6 inches. Such variations of flow were not localized to a single marker, but existed, to a proportional degree, over the full width of the glacier.

During the whole period of observation complete records of temperature, humidity, atmospheric pressure, and incoming radiation were maintained. An examination of the data shows that the glacier movements were unrelated to the first three of these. In the case of temperature this is only to be expected, for both Etienne's work at the firn station and the findings of past expeditions have shown that, without the presence of melt-water, the absorption of temperature by the lower layers is an exceedingly slow process. It is true that in the summer months a great amount of melt-water is present in glaciers, and the Taterat glacier was no exception. In certain localized regions (crevassed areas) the distribution of heat from the surface downwards is

greatly accelerated by the flow of melt-water. Judging from the observed data however it seems fairly certain that the main body of ice remains unaffected by day-to-day fluctuations of temperature, and that the jerkiness in the glacier movements must be due to some other cause. So far the radiation data have not been fully worked up, but to judge by similar observations carried out by a German expedition to Spitsbergen (not yet published) it seems likely that radiation may have a far larger influence on glacier flow than previously imagined.

Finally, it should be noted that the line of markers was only 300 yards above an ice-fall in which the glacier lost 500 feet in height. It is probable therefore that the sudden stresses set up in this ice-fall will be found closely related to the sporadic movements of the markers.

An examination of the time-movement curve shows a general tendency for a periodic distribution of maxima and minima values at intervals of ten days.

Another interesting outcome of the glacier readings is obtained if the mean speeds of the markers over the full period are plotted against the corresponding distances of the targets from the observing theodolite. The resulting curve is almost exactly parabolic.

Accumulation and ablation.[1] During the comparatively brief period (August 18–September 23) that observations were carried out at the firn station on the ice-cap, we could not expect an accurate picture of the annual accumulation and ablation at this altitude. The readings show however that the ablation during the summer is very small compared with the annual accumulation.

August 18–31:	Mean ablation per day ..	.. 2·0 mm. water
	,, accumulation per day	.. 4·4 ,,
	,, temperature (air)	.. 29·0° F.
September 1–23:	Mean ablation per day ..	.. 1·0 mm. water
	,, accumulation per day	.. 2·4 ,,
	,, temperature (air)	.. 25·4° F.

At all Danish stations on the west coast the monthly means of temperature (with the exception of July) lie below the values for August. It is therefore safe to assume that the ablation on the Sukkertoppen Ice above 4000 feet does not influence its behaviour to any great extent.

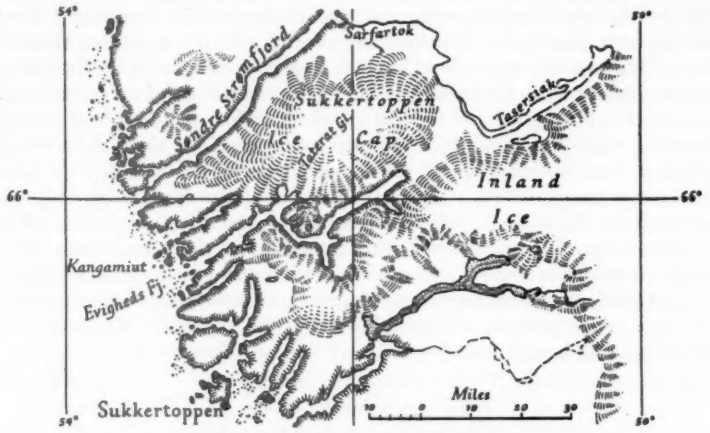
The accumulation of the previous nine to ten years can be determined from the investigations into the firn structure made at depths down to 18 feet. Firn and ice were found in alternate layers which were apparently continuous, the thickness of ice varying from 1–2 cm. near the surface up to 5–10 cm. at greater depths, which is in agreement with the observations of other expeditions in different localities.

Sometimes a firn band contained a number of very narrow ice-bands that were not continuous. Such bands were very marked and were clearly the result of alternate melting and freezing at the surface; each ice-layer had once been a surface ice-crust formed after a period of thaw. The majority of such crusts would obviously be found in summer and in consequence the firn layers accumulated in winter would show few, if any, ice-bands. In this way the

[1] The remainder of the glaciological and meteorological report is due to E. Etienne.

accumulation of the previous three years (back to the summer of 1935) was clearly shown. The mean annual accumulation (minus the summer ablation in each case) for 1935–38 was 65 cm. (cir. 3 feet) of firn or 340 mm. (13·4 inch) water. This value is comparable to the annual means of precipitation at Godthaab and Upernivik, being less than the former and higher than the latter. An analysis of the complete results will give the annual accumulation from 1929 to 1938. At present however only the mean annual accumulation for this period has been worked out to be 60 cm. of firn ice or 343 mm. water.

The change from firn to ice. It is of interest to discover the processes whereby the snow deposited on top of an ice-cap is eventually converted into blue ice. That pressure, melting, and recrystallization play an important part in the process is obvious, but the exact manner in which these occur is another aspect of the study of firn structure. There are two phenomena



Sukkertoppen Ice-Cap, West Greenland

which require explanation: that the thickness of the ice-layers increases with increasing depth (this has also been found by other expeditions); and that the temperatures of the firn down to 15 feet are constantly at freezing-point throughout the summer and remain at that temperature even a long time after surface temperatures are well below zero. An increase both in the density of the firn (exclusive of the ice-layers) and in the size of the firn-crystals with depth, as observed by Ahlmann, was not found to be the case in our investigations, though special attention was paid to this point. Temperature distribution is undoubtedly of primary importance. It has generally been supposed that the upper layers of firn are soaked with melt-water during the summer months, which trickles down to some 20 feet. It seems unlikely that this was the case with the Sukkertoppen Ice-Cap as the thicker layers—the first of which was at 2 feet—would certainly have stopped any vertical flow of water. An experiment carried out with a large section of one of the upper ice-layers showed it to be impervious to water. While this offers no explanation of the temperature distribution, it does explain the fact that

the ice-layers grow with increasing depth; each ice-layer stops the water draining away from the layer above it, and thus the firn immediately above the ice-layer becomes more and more "iced up." The very irregular shape of the upper surface of the ice-layers supported this view. The temperature gradients in the firn-layers are therefore due to convection by melt-water, while conduction is responsible for the distribution of heat through the ice-layers. A series of readings were taken on the conductivity and temperature of the firn which are likely to throw further light on the problem. In addition measurements of density (average density: firn-layers, 0·52; ice-layers, 0·865), and a series of photographs of ice-crystals and ice-layers at varying depths, should prove useful in any detailed examination of the results.

Meteorology

The observations and recordings at Glacier Camp and Igloo Camp were a part of the glaciological work, and also of interest in themselves. Two months were insufficient to collect any general evidence regarding climate. Some idea however of the local conditions and circulation along the valley can be obtained from the recordings and photographs of the cloud formations. On occasion photographs of fog and cloud formations were taken at hourly intervals; while the humidity and temperature readings show the various phases of local circulation, and the characteristics of the cold dry air from the ice-cap compared with the warm wet air of the fjord. Also of great interest were the sudden foehn winds which occurred several times during the expedition. Sweeping down with great rapidity from the north, they caused considerable melting both at the firn station and on the lower glacier.

The variations of daily mean temperatures at the two camps bore a marked similarity to one another. The monthly means for August and September at Igloo Camp are in each case 8·5° F. below those at Glacier Camp.

Mean temperatures:	Glacier Camp August 15–31	37·6° F.
	Igloo Camp August 18–31	29·0
	Glacier Camp September 1–30 ..	34·8
	Igloo Camp September 1–27.. ..	25·6

Radiation readings were taken at various times of the day, sometimes at Glacier Camp, and on other occasions at the firn station. Mean values of incoming radiation for varying altitudes of the sun were obtained from six hundred observations. The recordings at the firn station were in nearly every case 0·8 cal./sq. cm./min. higher than those at Glacier Camp, which gives an idea of the quantity of water vapour contained in a column of air, between the two camps, 3400 feet in height. At Glacier Camp a Robitzsch actinograph was used to record the total incoming radiation. Owing to the close proximity and height of the mountains surrounding the camp it is difficult to analyse these records, but they will be of considerable value in estimating the daily amount of radiation striking the lower glacier. They revealed at once that the average thickness of the clouds was very small: even on completely overcast days a large amount of radiation was able to penetrate through the clouds. This is in agreement with other observations in arctic regions.

The radiation balance of the surface is the amount of radiative energy

absorbed by the ground, *i.e.* the total incoming radiation less the reflected radiation and the outgoing radiation from the ground. This was measured with a new instrument developed at the Meteorological Observatory of Potsdam. The difference between the outgoing and incoming radiation is measured electrically as the temperature difference between two blackened discs, one of which faces the ground (absorbing all outgoing radiation) and the other the sky (absorbing all incoming radiation). Certain allowances are are made in the instrument for the disturbing effects of wind and varying air temperature. The galvanometer readings have not yet been worked out, but it may be noted that the albedo of the (frozen) snow surface was 88·69, *i.e.* almost 90 per cent. of the incoming radiation was reflected again.

Wireless

Through the efforts of Etienne, Messrs. Telefunken, of Berlin, generously loaned to the expedition a short-wave experimental transmitter and receiver, specially constructed at very short notice. In addition, the same firm supplied three portable short-wave wireless-telephony sets for communication between camps. Unfortunately the offer of this elaborate apparatus was not received until a short time before the expedition sailed. Had the extent of the equipment been realized earlier, we should have taken an expert to put in his full time at radio research. Etienne was the only member of the party with any knowledge of the subject, and as his time was already occupied with other work, it was impossible to take full advantage of our opportunities. On August 14 the apparatus was in proper working order for the first time, and contact was made with two American amateurs, who reported the reception as excellent. A day or so later Etienne got in touch with an amateur from Manchester, who also remarked on the clarity of the signals.

The receiver worked without a hitch on most nights; in September we picked up stations from all parts of the world, and even complained a little of its efficiency during the European crisis. In the early part of September, when four members of the expedition had returned to England, Etienne and Kershaw were working up at the firn station, while Mott was looking after the two lower camps. During a separation of ten days the real value of the portable wireless telephones became apparent. These remarkable little sets, one of which was installed at each camp, included a transmitter, receiver, and batteries, enclosed in a strong metal case, weighing in all about 60 lb. The aerial consisted of a 10-foot sectional pole supporting a star-shaped antenna. The sets were adapted either for morse or for telephony, working on wave-lengths between 50 and 60 metres. Despite the fact that Boulder Shelf was 8 miles away from Igloo, and 3000 feet lower (the two camps were invisible from one another), reception at all times during the day was perfect. We usually called in morse, and then switched over to telephony, which was often so loud that the volume control had to be adjusted to half strength.

Mount Atter (*Atters Bjaerg*) [1]

The highest and most impressive of the mountains in the whole of the Sukkertoppen region is bounded on the north side by a deep valley containing

[1] The name "Taterat" (included in the Admiralty Chart) was thought, in error, to refer to this mountain in 1936, and was used in the report of that expedition. The name

the upper section of the Taterat glacier, which divides the northern face of the mountain from the Sukkertoppen Ice. Seen from the ice-cap Mount Atter appears like some vast fortification of snow and ice. Giant buttresses of bare rock rise perpendicularly for 3000 feet from the main glacier, unbroken save for a series of deep-cut valleys containing hanging glaciers, and overshadowed by 50-foot cornices of snow. Above this impenetrable rock-wall a gently sloping glacier, contained between two long ridges that run roughly north-east and north-west from the summit, leads up to the base of the final pyramid. The summit itself consists of a cap of snow and ice 200 feet in thickness.

At the end of August an abortive attempt was made to climb Mount Atter. A party of three set out from the ice-cap station to cross the Taterat glacier at a convenient point and to find a route up the north wall. The descent to the glacier however proved so difficult that the attempt had to be abandoned. From the information gained on this journey and from a study of the available photographs it seems unlikely that there is any approach to the summit from the north or east, and the correct route is undoubtedly from the south *via* the tributary glacier that meets the Taterat glacier at the site of our base camp (Glacier Camp). The southern approach is almost free of avalanches and therefore far less dangerous than the north face, which is constantly menaced by the overhanging snow cornices.

At the end of September a careful survey of Mount Atter was carried out from a high snow-ridge above Igloo Camp. In one day a short base was measured by the subtense method and extended to nearly a mile. The summit, together with several other of the highest peaks, was then triangulated from the end of the long base. The height of Mount Atter proved to be 7300 feet.

It will probably vary however within limits of 20 feet during the year, due to ablation and accumulation.

At the end of August the motor boat took four members of the party back to Sukkertoppen. Etienne, Kershaw, and Mott were therefore left with three camps to maintain during September. Most of the instruments at the two meteorological stations were self-recording, so that either station could be left for a week without attention if necessary. For the first ten days, while Etienne and Kershaw were at Igloo Camp, Mott looked after the lower camps. After his return to the base however Etienne unfortunately sprained an ankle, which put him out of action for the remainder of the expedition. Therefore, since it was getting late in the season, it was essential to complete the work at the firn station and to evacuate Igloo Camp before the combination of deep snow and limited daylight made the approach glacier impassable. Little has been said so far of the difficulties encountered between Glacier Camp and Igloo. Though journeys were frequent between the two camps, the approach glacier to the ice-cap was steep with a maze of crevasses first

has been given by the Greenlanders to the snout of the main glacier referred to in this account. The name of Atters Bjaerg, which has now been officially passed by the Danish Government, commemorates the climber, M. F. Atter, who lost his life in the Sarfartok river on the 1935 expedition to this district.

longitudinal and then transverse. In late September even the lower parts of the glacier were under several feet of snow, and all but the largest crevasses covered. Limited time and personnel involved carrying very heavy loads: on the Igloo journeys our packs were on several occasions over 70 lb. and seldom, if ever, fell below 55 lb. On September 29 the firn station was evacuated, and a few days later Boulder Shelf was also abandoned. The main problem for the last few weeks was the transport of three-quarters of a ton of equipment down to the fjord base. Fortunately the weather remained unbroken for the first long spell, and six days of sledging, followed by two weeks' back-packing, completed the task. The last month was marred to some extent by the loss of a 20-gallon drum of oil. On returning to the fjord dump after an absence of only a month, we found that the snout of the glacier had advanced laterally by 100 feet, completely covering our original landing-place. The main store depot was fortunately some way up the moraine and well out of reach, so that as regards food we had no fears. The shortage of fuel however was acute, and we found ourselves reduced to a gallon of paraffin a week.

Our final camp was pitched on a small silt platform at the foot of the moraine and provided an excellent opportunity of studying the ice-cliff during the ten days we were there. We noticed that its greatest activity occurred soon after midnight with remarkable regularity. The period of maximum discharge was not so clearly defined during the day, but usually occurred early in the afternoon. It is of interest to note that these observations, casual as they are, agree roughly with those of Mr. Bradford Washburn in his paper on the South Grillon glacier in Alaska (*Geogr. J.* 87 (1936) 481–95). Before a major calving there were first a series of small falls, which gradually widened the gap behind an overhanging section of the cliff until the angle of its inclination with the vertical became so great that there was a sudden crack, and the whole slice broke away from the main body. Owing to the tremendous force with which they struck the water, discharges of this nature never produced ice-floes of any size. The largest floes were the result of calvings that occurred below the water-line, and would bubble up suddenly from beneath. A curious phenomenon, noticed both by Etienne and myself, was the occurrence of an initial backwash along the shore immediately after a calving had hit the water, but some time before the resulting wave had spread.

We were not sorry to see the motor boat when it arrived at the end of October, since our meagre supply of paraffin was nearly exhausted. Luckily the glacier remained fairly inactive while we loaded the ship far into the night, by the light of hurricane lamps. The next morning we looked our last on a scene which had become intimately familiar in its every aspect and which, despite a certain ferocity, had retained for all of us an irresistible charm.

Two delightful weeks were spent in Sukkertoppen Settlement, where the hospitality of the Danish Colony knew no bounds, before the arrival of the *Disko* to take us back to Denmark.

THE *SCHWABENLAND* IN THE ANTARCTIC

ON p. 206 of the *Geographical Journal* for September 1939 we had a brief reference to a German Antarctic expedition in the *Schwabenland*, of which no details were then available. We are now indebted to the Hydrographer of the Navy for the following summary, in translation, of a Deutsches Nachrichter Büro report dated 11 April 1939, received by him through the Foreign Office from the British Embassy in Berlin.

"The German Antarctic Expedition 1938/39, which left Hamburg on 17 December 1938, returned to Cuxhaven on Tuesday April 11. The leader of the expedition was Captain Ritscher and he was accompanied by a staff of scientists including an oceanographer, a biologist, a geophysicist, and a geographer. The ship, the well-known catapult ship *Schwabenland*, of the German Lufthansa, had been specifically chartered for the expedition, which was sponsored by the German Forschungsgemeinschaft of Berlin and was under the aegis of Field-Marshal Göring. Two 10-ton Dornier Wal flying boats accompanied the expedition.

"The *Schwabenland* arrived in January in the area where it was to work, namely the sector on the zero meridian of the Antarctic continent. 350,000 square kilometres of territory were photographed and in all 600,000 square kilometres reconnoitred by eye-observation and photography. Material was collected in the course of routine flights totalling in all over 10,000 kilometres, a distance corresponding to a quarter of the world's circumference. A further 2000 kilometres were covered in seven special flights.

"The territory reconnoitred forms a geologically self-contained section bounded on the east and west by an ice plain rising fairly sharply in the direction of the Pole and merging south of 74° in the Polar Cap some 4000 metres high. Between 2° East and 8° to 10° West the Polar Cap falls away to the north in high steep rock precipices between 73½° and 74° South.

"The photographic map material acquired by the expedition is unique. When the photographic prints are assembled, a photographic map will be completed such as no other land possesses of this part of the Antarctic continent. This is exceptionally important in view of the Norwegian claim to sovereignty over the part of the territory explored by the expedition, based on the Norwegian Order of 14 January 1939, reserving all rights as against Germany.

"The special flights provided *inter alia* exact photographic pictures of a strip of land studded with open lakes at 71° 10′ South and 11° 25′ East. The special flights further enabled landings to be made at the edge of the shelf-ice and the Hakenkreuz flag to be hoisted at several points of the coast of the Antarctic continent. During flights, at intervals of some 25 kilometres as also at all turning points, arrows with Hakenkreuz flags were dropped overboard.

"The flights during the first of three periods were carried out from the points 69° 10′ S., 4° 20′ W.; 68° 47′ S., 3° 47′ W.; and 68° 57′ S., 1° 5′ W.

"As a result of bad weather the *Schwabenland* on January 20 got into difficulties from which it only escaped through the piloting of one of the flying boats; in consequence it was decided to start work in the west and then to move over to the east, since ice conditions, it was hoped, would be better there. Accordingly flights during the second period were carried out from the points 69° 34′ S., 1° 17′ E.; 69° 47′ S., 6° 10′ E.; and 69° 34′ S., 7° 20′ E.

"A further change in weather conditions compelled the expedition at the end of January to move even farther east for the third period. In February 1939 a further flight was carried out from the point 69° 5′ S., 14° 45′ E. On this occasion the flying boat flew along and photographed the edge of the shelf-ice to about 18½° East, and was able to follow it with the eye to far beyond 20° East. A further flight was carried out from the same point on February 5; this concluded activity in the air, since meteorological reports indicated further deterioration in weather conditions.

"On February 6 the expedition started homewards since it was considered that, in view of the deterioration in the weather and ice conditions, further activity would be attended by unwarranted risk. Furthermore, it had been established that in the case of one of the flying boats, at temperatures below minus 15° the trimming-gear no longer functioned. Otherwise the flying boats functioned extremely well and carried out all requirements to schedule without incident.

"The most southerly point reached by the expedition was 72° 44′ South and 0°. The most westerly point reached was 71° 23′ South and 4° 50′ West. The most easterly point reached was 72° 10′ South and 16° 30′ East. These points were marked by Hakenkreuz flags.

"The *Schwabenland* returned along the zero meridian, where oceanographic measurements were carried out. The expedition is considered to have been a great success and well worthy of Germany's great achievements in the past in Antarctic exploration. The scientific results of the expedition are also said to have been exceptionally good. The meteorologists carried out all kinds of measurements. 119 radio soundings (*Radiosonderaufstiege*) were carried out, of which 36 were within the South Polar Circle. 31 of the soundings reached a height of over 20,000 metres; only 11 were under 12,000 metres and the average was 18,000 metres. The biologist is reported to have brought back, *inter alia*, 5 King and 3 Adelie penguins, of which no living examples have until now reached Germany."

This report appears to be that of the captain, handed to the D.N. Büro on the day of his arrival. An article in *Petermanns Mitteilungen* for June 1939 gives some more details. Captain Ritscher, the leader, is a survivor of the Schröder-Stranz Arctic Expedition of 1912–13. The *Schwabenland* was only three weeks in the Antarctic, and during these weeks there were only three flying periods, of 3, 2½, and 1 days, during which time the two machines flew 16,000 km. The most southerly point is given as 74° 25′ S., 0° 20′ W., and there is no mention of any landings. The article ends with a quotation from the journal *Der Vierjahresplan: Zeitschrift für Nazionalsozialistiche Wirtschaftspolitik* for 5 May 1939.

From the British Library of Political and Economic Science we have been able to borrow this copy of *Der Vierjahresplan*, which is well illustrated with photographs of the *Schwabenland*, the catapulting track, the device for launching the sounding balloons, and several pictures of the shelf-ice, and of high mountains nearly bare of snow, but with no indication of their position. The region in which the *Schwabenland* worked is described as "an unknown part of the Antarctic, south of Bouvet Island and lying about the zero meridian, the edge of whose shelf-ice had occasionally been reached." The map which we published in the *Journal* for September 1939 shows that Bellingshausen in 1820, Biscoe in 1831, the *Quest* in 1922, the *Thorshammer*

in 1937 had all worked off this coast, and that the R.R.S. *Discovery II* was there a few weeks after the *Schwabenland*.

Our map shows that the photographic surveys of Mr. Lars Christensen's staff did not extend quite so far west, and the German photography is the first inside the edge of the shelf-ice. But the German claim that "350,000 square kilometres of land have been photographed to form the basis of a map of a sort which is not available for any other part of the Antarctic continent" cannot be admitted, at any rate until we see how they can get out of the difficulty that there is no ground control; still less the boast that "none of the countries which has raised claims to sovereignty in the Antarctic disposes of anything approaching the knowledge of the regions claimed, or of map material of such precision, as does Germany over the land discovered by the G.A.E.": land on which no German has ever set foot.

Such claims are not in keeping with the moderate and careful way in which *Der Vierjahresplan* discusses elsewhere in its article the interesting political questions involved in the sector principle, which works in contrary ways round the two poles: in the north claiming whatever may be known or found in a sector of sea to the north of established land possession, in the south claiming the sector of a continent which forms the hinterland of a known coast or shelf-ice edge. The German Government is said to have "made the necessary reservations" in answer to the Norwegian claim to a sector, apparently on the ground that "the basis for a valid international claim to unclaimed land is the will to occupation, that is to say, to settlement of the land and to continued exercise of government and sovereignty." Yet to do that requires something more than flying over it, photographing it, and dropping flags upon it for a day or two.

THE TURKISH RAILWAY SYSTEM

ON October 21 last the Turkish Minister of Public Works formally opened the new railway between Sivas and Erzurum. The line leaves the Ankara–Sivas–Malatya line east of Kangal and runs *via* the valley of the Firat, the most northerly headwater of the Euphrates, and Erzincan, a distance of approximately 400 kilometres. As the valleys are narrow and steep-sided, it was necessary to build twenty-two bridges and many tunnels, all the work being carried out by Turkish engineers and workmen. The track is a single line of standard European gauge. From Erzurum there is a narrow-gauge track, laid by the Russians in 1916, to Sarikamiş, whence there is a

The Turkish railway system

Russian broad-gauge line *via* Kars to the Russian frontier. Thus to complete an east–west line through Turkey there only remains to convert the 230 kilometres between Erzurum and Sarikamiş to standard gauge, and it is intended to proceed with this. We have received through the courtesy of General Pertev Demirhan an album, 'Erzurumun işletmeye açilisi,' issued in celebration of this opening and containing a large number of photographs of the works carried out, both on this railway and on others in Turkey.

This is one of several important lines which have been built in the last fifteen years to provide Turkey with a comprehensive railway system. Before that time, with the exception of the Anatolian Railway to Ankara and Konya, and the Baghdad Railway from Konya to Syria, lines were confined to those running inland from the Mediterranean coast, principally from İzmir (Smyrna). The strategic handicap of this lack of railways was emphasized between 1915 and 1922, and its economic effects, particularly in eastern Anatolia, where railway building was vetoed by the Russians, are obvious. In taking over and developing the railway system, the Turkish Government

aimed at supplementing the existing lines in the west and providing through longitudinal and transverse routes in the centre and east.

In the west, two branches have been added to the Anatolian Railway: one leaves it south of Eskişehir and runs westwards through Kütahya to Balikesir, opening up a valuable mining and agricultural region. The second branch runs south from Afyonkarahisar to Karakuyu, where it joins the Aydin line from the west. It is proposed to run a line southwards from here to the Mediterranean at Antalya.

In central Anatolia the Ankara line was carried south-west to Kayseri and thence north-east to Sivas; from Kayseri also a line was built southwards to join the Baghdad Railway at Ulukişla. The Sivas line, from which the Erzurum line branches, continues to Malatya, where it joins a second connection with the Baghdad Railway at Fevzipaşa. The latter line has been continued eastwards of Malatya to Diyarbakir; when completed to the boundary at Cizre it will take the place of the section of the Baghdad line as originally planned, which runs along the Syrian frontier. It is known as the "copper line" from its connection with the mines at Ergani.

In the north the Black Sea coast has been linked with the interior by two lines: one from Zonguldak, which serves the coal-mining area of Eregli, the chief source of Turkish coal, to Irmak, on the central line 45 kilometres east of Ankara; the second from the important harbour of Samsun to the Sivas Railway at Kalin, 25 kilometres to the west of Sivas. In addition to a central west–east line, therefore, the southern coast on the Mediterranean has two somewhat roundabout connections with the Black Sea coast. The proposed extensions of some of these lines to the boundaries of Iran and 'Iraq would ultimately offer these countries through communication with the eastern Mediterranean and Black Sea.

The total length of the new lines mentioned above is over 3000 kilometres, and several minor branches have been built. This development will make Sivas, Malatya, and particularly Kayseri, centres of considerable importance.

VEGETATION OF THE BRITISH ISLES

THE BRITISH ISLANDS AND THEIR VEGETATION. By A. G. TANSLEY. *Cambridge: University Press*, 1939. 10×6½ *inches;* xxxviii+930 *pages; illustrations and maps.* 45*s*

FOR more than twenty years the first and only systematic study of British vegetation has been out of print, and the serious student has found the greatest difficulty in obtaining 'Types of British vegetation,' edited by Tansley, although it was published as recently as 1911. The volume under review is its long-awaited successor and, clearly, the wait has been worth while. A modest octavo volume designed for the pocket has been replaced by a tome in the large format of the *Journal of Ecology* extending to nearly a thousand pages and illustrated by 162 plates with 418 photographs—including most of those from the old book and a large number from the *Journal of Ecology*—as well as 179 text-figures. The growth of the study of ecology is as much associated with the name of Tansley in Britain as it is with F. E. Clements in America. For many years at Cambridge, and later as Sherardian Professor of Botany at Oxford, Tansley has been largely instrumental in weaning young botanists from the old obsession with "pickled" specimens in the laboratory to the study of live ones in the field. It is not, for example, many years since the reviewer completed the whole of an Honours course in a British university without seeing—officially—a living plant growing outside a laboratory. As editor of the *Journal of Ecology* for the first twenty-two years of its existence, from 1916 to 1937, Tansley has been in a unique position to assess the results of ecological work, and it is not surprising that his *magnum opus* should bear throughout the marks of a master hand.

The preface is unusually important in that it presents, in brief, the author's creed (restated at greater length in Chapter X, on the nature of vegetation) and is thus an essential prelude. Clements originally restricted the term "climax" to the climatic climax, recognizing development through a number of "seral" stages. This relatively static conception is changed by Tansley into an essentially dynamic one in which he recognizes that natural and semi-natural vegetation are constantly changing; where the environmental factors reach a stage of relative stability or equilibrium the vegetation reaches also a stage of relative stability which may be called a "climax." Thus the different types of pasture in Britain have reached a stage of relative stability, though grassland is scarcely a climatic climax at all in this country. Here the stabilizing factor is zoogenic or human; undergrazing or overgrazing represents a change in the zoogenic factor which will automatically be reflected in the plant community. This change in point of view is comparable with the change in the geographer's point of view from climatic determinism to the recognition of reciprocal and constantly changing interaction between man and his environment.

In Part I (Environment) and Part II (History), which occupy rather over a quarter of the book, Tansley deals with the geographical background of British vegetation and expresses the hope that his work will prove useful to students of British geography and others whose interests are not narrowly confined to plant ecology. He may be reassured on this point; no serious geographer can afford to neglect Tansley's work. He modestly suggests that his material for these introductory sections has been taken from "good secondary sources," but the result has a piquant interest as a summary of the geographer's own sphere by a master hand trained in other disciplines. On occasions, as in the references to eskers (p. 26), the automatic reference to the Tertiary granites of Devon and Cornwall, the table of post-glacial chronology (p. 150, authority unstated), he is on very

thin ice and sometimes he passes over important and relevant recent developments (as in the twice reproduced section across the Weald which ignores the significant faceting or peneplanation demonstrated by Wooldridge), but in large it would be hard to better this geographical introduction.

Maturity in thought and expression does not hesitate to admit past errors or imperfections in judgment, and it is freely admitted that in 'Types of British vegetation' the great importance of climate (especially micro-climatic studies) was overlooked in an over-emphasis on soil, and that such dogmas as the rigid distinction between damp and dry oakwood were overstressed. Sections which have survived from the earlier work are frequently the weakest. Thus the section on climate and agriculture (pp. 74–77) is particularly disappointing in view of the suggestion elsewhere that a training in ecology should be an essential prelude to a forestry or agricultural course. There is still a reluctance to accept the human factor, to recognize that the essential characters of half the soils of Britain are due to their agricultural history, and that the development of weeds in cultivated land is the most significant of all seral stages, at least so far as area is concerned.

Several of the earlier chapters form the best and most succinct summaries now available of such subjects as British soils (Chapters IV and V) and the distribution of forms of vegetation (Chapter IX), but in the chapter on the history of vegetation it is surprising to find so little consideration given to the time and importance of the separation of Britain from the Continent. It would be interesting to know how far the botanical evidence supports the contention of the reviewer that the remarkable and apparently sudden change of climate from the Boreal to the Atlantic period was actually occasioned by this separation and the consequent establishment of an oceanic circulation round the British Isles comparable to that of the present day.

Parts IV to IX, occupying the remainder of the book (pp. 241–902), are concerned with the detailed description of British natural and semi-natural vegetation. Of necessity both the exact approach and the fullness of the descriptions are dependent on the existence of detailed studies. Full use is made of all available, and the only criticism from the non-specialist is that the author might have afforded a little more help by drawing on his own store of knowledge. The reviewer attempted to abstract a list of grasses characteristic of managed water meadows in southern England, but found insufficient guidance despite the local and detailed studies quoted in full, and similarly searched in vain for an ecological reason for the superior carrying capacity of well-known "fatting" pastures of the Midlands. But these are but the smallest criticisms of what is undoubtedly an enduring monument to a great botanist and a great scholar.

L. D. S.

REVIEWS

EUROPE

MODERN GEOGRAPHY. Book III. Europe. By D. M. PREECE and H. R. B. WOOD. *London: University Tutorial Press*, 1939. 8×5½ *inches;* viii+312 *pages; illustrations and maps.* 3*s* 6*d*

This volume by two teachers of geography provides a clear account of a complex continent. The attempt at clarity has occasionally led to the omission of information and thereby reduced the value of some of the regional accounts. About one-twelfth of the book is devoted to the physical background as such, but there is additional information in the regional chapters which deal with soils, topography, and climate as well as with economic development. The photographic illustrations are useful and the line diagrams clear. Some of the maps suffer owing to the unequal value to be given to the upland shading—*e.g.* Fig. 60, the southern part of the Rhine basin appears as impassable to routes as the heights of the Black Forest. This volume can be confidently recommended as a useful text for pupils preparing for School Certificate examinations.

A. C. O.

ENGLAND'S WATER PROBLEM: a survey of rainfall, drought, and distribution. By H. SPENCE-SALES and JOHN BLAND. *London: Country Life*, 1939. 9×5½ *inches;* xii+274 *pages; illustrations.* 18*s*

The spring drought of 1938 resulted in considerable shortage of water in rural areas and, with recollections of the restrictions imposed on existing supplies in towns during the droughts of 1933, 1929, and 1921, the editor of *Country Life* suggested to the authors that the subject seemed worthy of special investigation. They took up the idea with enthusiasm and toured the country to see the local difficulties and consulted authorities on various aspects of the problem. Before the investigation had been completed there were abundant rains, but their experiences seemed of sufficient interest to be placed on record against the next droughts, which are certain to occur. The book is worth reading as a study of a complicated subject, written in a manner likely to arrest the attention of the ordinary reader. It gives information about the lesser known parts of the country and is well illustrated.

An abundant and reliable water supply is of fundamental importance in any country before the fullest use can be made of its potential wealth. In England four out of every five persons have access to a piped supply giving ample water in all circumstances, although possibly restricted during the severest drought. These fortunate individuals live in the cities, towns, and larger communities. Those in the more scattered rural districts have to rely on meagre supplies, which may fail altogether in dry weather. The "water problem" arises mainly from three reasons: (1) schemes for improvements cost money and the best method to employ is not clear to the general public; (2) droughts occur infrequently and are not long sustained, and it is difficult to stir the public consciousness sufficiently to carry out such schemes when wet weather prevails; and (3) the risks of hardship arising from an insufficient supply are confined to a small part of the population.

In a chapter on the planning of water resources and supplies an outline is given of the evolution of public water supply legislation and the development of these undertakings. The authors recognize that it would not be economically feasible to connect all outlying farmsteads with a piped supply and recommend private installations, which they consider in many cases could be carried out

readily and inexpensively. The authors attribute the present position mainly to the inability and disinclination of owners and tenants to add to their capital outlay in view of the low agricultural prices prevailing. Definite recommendations are put forward, but the authors conclude that a greater confidence in the future of agriculture is necessary before substantial improvement in the water problem can be expected. J. G.

THE LAND OF BRITAIN: the report of the Land Utilisation Survey of Britain. Edited by L. DUDLEY STAMP. Part 4. Orkney. By A. C. O'DELL. *London: Published for the Survey by "Geographical Publications,"* 1939. 11 × 8½ *inches; 191–263 pages; maps and diagrams.* 2*s* 6*d*

The paper gives a very attractive and graphic picture of the islands, and one appreciates throughout the skill of a trained geographer in selecting and setting out his material. The Orkneys emerge as one reads with colour and reality. A more complete picture of present-day farming conditions and a fuller account of the successful poultry industry would however have been welcome. The success of cooperation in this industry is in striking contrast to its failure in other Scottish counties, and light thrown on the reasons for this during Mr. O'Dell's investigations would have been of value. Some of the criticisms one makes may be due to the form imposed on the paper; perhaps a statement describing it might have been included. The scale of the small maps differs to a degree that makes comparison impossible, and although photography is difficult in Orkney for climatic reasons, photographs might have been obtained showing more clearly the difference in the type of farmstead in the Scapa Gap and Eday than do those on pp. 213 and 220. There is a most interesting map showing early land utilization by means of the translation of Norse names; a method which might be more widely used. Mr. O'Dell has made good use of the early records he has been so fortunate as to find and gives some delightful quotations. In Fara, for instance, in the sixteenth century "the boys sing to the cattle. The whole island is full of corn and fish." G. M.

THE LAND OF FRANCE. By RALPH DUTTON and LORD HOLDEN. *London: B. T. Batsford,* 1939. 9 × 5½ *inches;* viii + 152 *pages; illustrations and location-map.* 8*s* 6*d*

This book, which is a commentary rather than a guide, has been read and tested after a holiday which covered many of the districts described, and it can be pronounced excellent. It is divided as follows: Normandy and the Breton Peninsula, Alsace-Lorraine and the Northern Plains, the Château country, the Île-de-France, Burgundy, the Biscay coast and the South. There is a good introduction which displays an intimate knowledge of the French character, and there are observations on food and drink. The authors obviously know France and the French very well indeed.

Much of France, which was holiday-making when this book was published, is now organized for war. Much space is devoted to provincial life, but even the smallest towns must now be denuded of able-bodied men, the cafés without waiters, and the motor coaches, which a few months ago were carrying travellers from one end of France to the other, are now used for the transport of troops to the front. Bowls must now be played by boys, and only patriarchs can be fishing the rivers. To that extent the book is out of date. But the pictures are superb. They cover every aspect of French life without neglecting archaeology and architecture. The walls of Aigues-Mortes, the castle of Tarascon reflected in the waters of the Rhône, the strange, rocky desolation of Les Baux, the Roman remains at Nîmes, Arles, St. Remy and Vaucluse, the little hill towns of

Provence—here, if anywhere, one might look for peace. Yet how many marches and counter-marches, how many conquests they have witnessed. The background of each one of them is war. Every inch of France has been fought over, but the wounds are quickly healed. This book reminds us again that France and the French spirit are unchangeable and indestructible. M. L.

LA POLITIQUE COMMERCIALE DE LA FRANCE. By RENÉ HOFFHERR. (Centre d'études de politique étrangère. Travaux . . . No. XI.) *Paris: Paul Hartmann*, 1939. $8\frac{1}{2} \times 6\frac{1}{2}$ *inches;* 378 *pages.* 30*fr.*

GÉOGRAPHIE ÉCONOMIQUE ET SOCIALE DE LA FRANCE. By PIERRE GEORGE. *Paris: Editions Sociales Internationales*, 1938. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 272 *pages; maps.* 20*fr.*

The first of these works is the report of an investigation undertaken by the Centre d'études de politique étrangère with the aid of representatives of ministerial departments and certain university and technical experts. It deals with the effects on the traditional commercial structure of France of population movements, of the play of politics and of organized group interests, and finally of state interference, and gives a close analysis of the efforts France has made to adjust her internal and external economy to the changing conditions of the last quarter of a century. In the second work M. George supplies, in a series of regional descriptions followed by a sketch of the broad features of the economic structure of France, the geographical background necessary for the full appreciation of the report.

Although France, in her almost unique position as a country whose agricultural and industrial interests are nicely balanced, has the great advantage of being almost self-sufficing in essential food materials, yet the rising standard of living has increased her dependence on imported colonial wares, while her own colonies will require the expenditure of much capital before they are in a condition to provide useful markets for French products (George, p. 262). Her rural economy, which, in response to competition from the bulk food-producing countries had gradually evolved compensation by the development of specialities, has experienced the closing of her markets one by one; prohibition, luxury taxes, protective duties severely damaged her wine, silk, and *primeur* industries. The control of the silk market passed to the United States of America. These specialist activities however, being based on permanent geographical characteristics (*e.g.* natural variety of climatic and soil conditions, large areas where highland valleys encourage the preservation of local skill and processes), have always been able to re-establish themselves under improving world conditions. It is the large-scale industries, as M. George points out (pp. 228, 229), and particularly those which have not grown, as it were, out of the soil, but have been planted ready-made with their large-scale complex structure, that have suffered and are like to suffer permanent damage from world crises and upheavals. M. George cites the steel industry of Lorraine, which, in contrast to that of the Nord, has suffered from the complications arising from dependence upon foreign capital, foreign commitments, foreign labour, and imported coal and coke. H. O.

LES LIMAGNES DU SUD ET LEURS BORDURES MONTAGNEUSES: étude de géographie physique et humaine. By LUCIEN GACHON. *Tours: Arrault et Cie*, 1939. $11\frac{1}{2} \times 8$ *inches;* 474 *pages; illustrations and maps.* 16*s*

Monsieur Gachon has written a comprehensive regional survey of the middle reaches of the Allier river and the bordering uplands that flank the valley on either side. In this 60-kilometre stretch, from the Velay mountains in the south

to the Clermont-Ferrand lowland, the Allier is the unifying factor in a country of great diversity. While the mother-stream drains the marly sediments of successive basins, or *limagnes*, its immediate tributaries drain to the east the crystalline uplands of Livradois, and to the west the volcanic heights of Mont d'Or, Cezallier, Cantal, and the dissected crystalline plateau of Montchamp and La Margeride.

The author has not unnaturally found some difficulty in coordinating these diverse and distinct geographical units, and this is particularly apparent in his treatment of the geomorphology. Nevertheless, taken individually, the geomorphology of each natural region is an excellent and detailed study, supplemented by the inclusion of a well-planned map. In a chapter on climate M. Gachon very sensibly treats the climate of the region in relation to the Massif Central and Europe as a whole, the micro-climate being interpreted in the light of statistics available. The last three chapters, on vegetation, soils and drainage, are somewhat superficial and might have been developed more fully.

It is in the human geography of the region that the author's chief interest lies. In the 358 pages devoted to human problems the interrelationship between mountain, plateau, and plain is made clear. Here one finds the coordination of the three geographical units, the dissected crystalline plateaux or *pays coupes* receiving special consideration since not only are they transitional between highlands and lowlands, but, like their homologues in other parts of the Massif Central, they have not hitherto been made the subject of research.

The most stimulating discussions are those on land utilization, evolution of land tenure, the adaptation of the peasant in his mode of living and the architecture of his homestead to the exploitation of the land; and on the history of the population from prehistoric times to the present rural population depression. The decrease in the rural population first manifested itself here towards the middle of the last century, and the causes elicited for this diminution throw more light on a subject common to the greater part of the Massif Central.

In his researches into the human geography the author has justified his choice of a region of components so diverse. Few geographers are as qualified as Monsieur Gachon to write on this locality. A native of the country, and now Professor of the École Normale, Clermont-Ferrand, he has had every opportunity of studying the terrain in all its aspects. To those interested in the geography of the Massif Central, and the Auvergne in particular, this book can be recommended. S. A.

ASIA

CYLINDER SEALS: a documentary essay on the art and religion of the ancient Near East. By H. FRANKFORT. *London: Macmillan and Co.*, 1939. 10×7½ *inches;* xlviii+328+xlvii (*plates*) *pages; illustrations.* £2 2*s*

The cylinder seal is well known to visitors and collectors in the Near East. It is a small cylinder, usually of stone, incised with various designs, most often religious or magical, round its length. It was an early invention of Mesopotamia for use upon the clay tablets which formed the principle vehicle of writing. Rolled over these documents it easily impressed on them its owner's mark, and served much the same purposes as seals in the Western world. Cylinder seals continued in use in Mesopotamia and in adjoining countries until Greek times. Thus the variety and content of their designs form, when gathered together, a unique, comprehensive, and supremely valuable corpus of information about the history, ideas, artistic influences, and ability of successive periods, much as Greek vases have done for Greece. Yet these seals have been

the object of extremely few general studies of importance. The last was that of W. H. Ward in 1910, an admirable book in its day but in recent times much antiquated. Dr. Frankfort, a Dutch archaeologist hitherto well known for his fruitful excavations in the Near East and his work on prehistoric pottery, has produced, in what is for him a fresh field, a complete and masterly history of the subject which will remain for long a classic of archaeology. Undaunted by the mass of minutiae inherent in his subject, he never loses his grasp of his main themes, and can always discern and put into words the thread of unity of style which runs through the numberless manifestations of example. But his work goes further than forming an important contribution to the study of ancient art. In a succinct and stimulating epilogue he explains the significance of the art which he has illustrated, and touches on the whole problem of the mutual relations of the arts of East and West in antiquity and in the Middle Ages, and the little-suspected indebtedness of the latter to the Babylonians and Assyrians who had passed away long previously. Dr. Frankfort's book cannot therefore fail to have a very wide interest and appeal. R. D. B.

FAMOUS CITIES OF IRAN. By LAURENCE LOCKHART. *Brentford, Middlesex: Walter Pearce and Co.*, 1939. 10×7 *inches;* 116 *pages; illustrations and maps.* 7*s* 6*d*

For lovers of Iran this book comes as a welcome contribution to its past history, and what is occurring to-day in its great modernization. For those visiting or working in the country, it is an admirable guide to the cities and towns that have made Iran famous in past centuries. Condensed into short accounts of each place, for those not able to read exhaustively the longer volumes on Iran's past and present, the book gives a vivid and clear story of its history; its influence on the outer world in past centuries, and the colossal task that its present ruler has undertaken in placing his country in the front rank of those which are putting on the cloak of modernization with courage and vigour. No book on any country carries sincerity and conviction unless the author has profound and intimate knowledge of it and loves it for itself. Readers will sense that atmosphere in Mr. Lockhart's work. The photographs, although they cannot show the green and blue of the tiles, assist the reader to visualize the mosques and monuments that are known to the world. For those travelling in Iran there is a local Baedeker available, but Mr. Lockhart's volume should be in their pockets, before they leave these shores, as a perfectly condensed encyclopaedia on the cities of Iran to-day. R.

GESCHIEDENIS VAN NEDERLANDSCH INDIË. Edited by F. W. STAPEL. Deel III. A. De oprichting der Vereenigde Oostindische Compagnie. B. De Nederl. Oostindische Compagnie in de zeventiende eeuw. By F. W. STAPEL. *Amsterdam: "Joost van den Vondel,"* 1939. 12½×9½ *inches;* 536 *pages; illustrations and facsimile maps. Fl.*15

This third volume of a new History of the Dutch East Indies deals with the formation of the Dutch East India Company and its operations up to the close of the seventeenth century. There is no chapter in the world's history more vivid and adventurous than the story of the rival Dutch and English companies during this period; and the reader who has time and patience to delve into this unwieldy mass of detail concerning every individual ship and the life-history of every "admiral" (as the Dutch called the commanders of their fleets) will find much to interest him. The book's value as a work of reference is indisputable, but the lack of any index in this volume is a serious omission. It is further impaired by its lack of chronological sequence and the author's irritating habit of

returning to pick up lost threads, so that the student is constantly finding himself back at a point he had passed decades ago.

One of the most remarkable facts revealed by this exhaustive record is the amazingly efficient organization of the Company's far-flung activities. Despite lack of communications, and the inevitable restriction of sailing-ships' movements by the monsoons, the whole great mechanism seems to have worked with a precision that could scarcely have been improved upon. The powers conferred by the States General of Holland upon a company which existed ostensibly for the purposes of trade were extensive. It could "make treaties with Princes and Potentates, build forts, enlist soldiers, and install Governors": privileges for which the Company paid 25,000 guilders, reinvested by the State in the enterprise, so that it might enjoy some of the profits. The original capital invested amounted to nearly 6½ million guilders. Included in this were some enormous individual holdings, one of the largest shareholders being a German, who held nearly four times as many shares as did the State.

The first appearances of the Company's ships in Eastern waters were hailed with delight by native princes, who saw in the new arrivals useful allies against the Spaniards and Portuguese, and promised rich cargoes in return for their help. This suited the Company's policy, which was to sweep their trade rivals off the sea. But supremacy once assured, oppression of the natives by the Vereenigde Oostindische Compagnie (generally known as the "V.O.C.") was ruthless, and the tale of their conquest of the East Indies contains some of the grimmest records in colonial history. Unlike some Dutch historians, Dr. Stapel cherishes no illusions concerning the methods employed by the Company's servants, and makes no attempt to whitewash the most ruthless of them all: Jan Pieterszoon Coen, whose barbarities are generally ignored in his fame as the founder of the Dutch East Indian empire. The story of his devastation and depopulation of Banda, the group of islands formed of the ridges surrounding the crater of a now-submerged volcano, is related at length. It is a pity that in a work of such redundance the subsequent history of Banda and the *perkeniers* living like princes amid great households of slaves, in mansions built on the nutmeg-estates formed from the murdered natives' groves, receives such scanty mention. Most of those mansions still stand: many empty and some ruined by recurrent eruptions of the "Fire Mountain" that dominates the group; and one could have wished to learn more of their story, and of the half-deserted town of Banda Neira with its narrow, high-walled streets, that was once the nutmeg-princes' metropolis.

A full account of the famous "Amboyna murders" is given. The author is at pains to emphasize the legality of the proceedings, in view of the alleged confessions (extracted by torture on the rack) of the Englishmen accused of conspiracy. "Although one may admit that the sentences were severe," he remarks, "one must not call them murder." But the idea that twenty tradesmen, one of them a barber, could have proposed to seize the huge sprawling fortress of Ambon, so well placed far inside the bay enclosed by this queer, horseshoe-shaped island, seems too ludicrous to be considered seriously.

One chapter of the book is devoted to the contributions made by the Company's servants in other fields than mere trade expansion and conquest. Among these was the famous naturalist Rumphius, who spent his whole life of study in the Indies. Geography owes much to the Company's navigators, who explored many new sea-routes. It was the Governor of Java, Van Dieman, who sent Tasman out on his voyages, when he charted some of the Australasian coasts; and when, too, he made the celebrated error whereby until the middle of the eighteenth century the island of New Guinea was marked on all maps as part of

the Australian mainland. It was only when the English arrived at Manila in 1762 that Torres's journal came to light, recording his sailing in 1606 between New Guinea and Australia, along the strait that Cook later named Torres Strait. The Company's activities in Persia, India, China, Formosa, the Cape, and Indo-China are all covered in detail, as well as those in the East Indies.

The illustrations are particularly fine. They consist of reproductions of historic documents, among them the original "Octrooi" granted to the Company in 1602, and a number of interesting prints of Batavia and other now familiar places in Java and the outer islands.

One could wish that the wealth of material so patiently collected in this volume might be disentangled from the mass of encumbering detail, and the story of the "V.O.C." told in such a way as to make its dry bones live; in an edition moreover that could be studied without the aid of a reading-desk. The present one is considerably heavier and more bulky than a volume of one of our largest encyclopaedias. H. W. P.

L'ÉVOLUTION ÉCONOMIQUE DE L'INDOCHINE FRANÇAISE. By CHARLES ROBEQUAIN. (Centre d'études de politique étrangère. Travaux . . . No. XIII.) *Paris: Paul Hartmann*, 1939. $8\frac{1}{2} \times 6\frac{1}{2}$ *inches;* 398 *pages; maps and diagrams.* 40*fr.*

Professor Robequain has written an admirable summary of the pioneer researches of Goudal, Gourou, P. Bernard, and Y. Henry. Agriculture, which is the occupation of three-fourths of the Indo-Chinese, has been largely left to a supplementary study of soil utilization now in preparation by the Tonkinese specialist P. Gourou. A reasonable sobriety is the keynote of Robequain's work, and this has led him to ignore the sensational aspect of Indo-China's history, as well as to avoid ultra-utopian optimism.

The most original sections of this book are analyses of the colony's population, of the investment of private capital, and of Indo-China's nascent industries. It is from the angle of its future industrialization that Robequain attacks the fundamental commercial problem of Indo-China: its place in the French imperial scheme *versus* its geographical alignment with Far Eastern markets. The depression accentuated the post-war tendency for this colony to trade chiefly with the mother country, and also for the latter to assume far more the rôle of protector as well as exploiter of her colony's resources. Robequain is a partisan of the traditional French policy of seeking commercial compensation within the imperial orbit, but he recognizes the artificiality of such distant exchanges, as well as the impossibility of making even the second largest colonial empire in the world self-sufficing.

Within the country, Robequain finds the central economic problem to be that of over-population, and it is in terms of human life that he interprets charts and statistics. One can only wish that the author had gone further in sketching the social implications of the colony's economic evolution. He realizes that the problems of labour are psychological, and that the uneven distribution of population can be only regulated and not resolved by governmental decrees. He feels that Indo-China has on the whole benefited by being drawn into economic line with the West, and that the Annamites are realizing this, now that the era of great public works appears to be drawing to a close. Professor Robequain endorses the growth of rural industrialization, under a prudent but not paralysing administrative hand, and finds no inherent incompatibility in the rôle of the white and indigenous elements, always providing the Government keeps a firm hand on the reins. V. T.

AFRICA

THE NILE BASIN. By H. E. HURST and P. PHILLIPS. Suppt. to vol. II. Measured discharges of the Nile and its tributaries from 1928 to 1932. (Ministry of Public Works, Egypt. Physical Department Paper No. 33.) vii+735 *pages*. Vol. V. The hydrology of the Lake Plateau and Bahr el Jebel. (Physical Department Paper No. 35.) viii+251 *pages; maps and* 107 *plates*. Second Suppt. to vol. IV. Ten-day mean and monthly mean discharges of the Nile and its tributaries for the years 1933–37 and normals for the period 1912–37. (Physical Department Paper No. 36.) v+249 *pages*. Second Suppt. to vol. III. Ten-day mean and monthly mean gauge readings of the Nile and its tributaries for the years 1933–37 and normals for the period 1912–37. (Physical Department Paper No. 37.) 291 *pages*. *Cairo*, 1938–39. 11×7 *inches*. *P.T.*50; 100; 50; 50

Vol. I, containing a general description of the Nile basin, its topography and meteorology, P.D.P. No. 26, 1931, has already been noticed (*Geogr. J.* 79 (1932) 514). Besides this and the volumes now under review, the work comprises: vol. II. Data of observed discharges up to 1927 (1932); vol. III. Ten-day mean and monthly mean gauge readings up to 1927 (1933); Suppt. to vol. III, 1928–32 (1935); vol. IV. Ten-day mean, monthly mean, monthly, and annual total discharges up to 1927 (1933); and Suppt. to vol. IV, 1928–32 (1933).

We understand that vol. VI, on the hydrology of the White, Blue, and Main Niles, is in preparation and that there may be a volume of rainfall statistics. Dr. P. Phillips died in 1937, but he contributed considerably to the whole work.

Three of the volumes now under review are composed of data, and while these pages of figures are hardly of interest to the general reader they are essential to any who have to discuss the hydrology or work out projects. It is most satisfactory to have the figures, which have been costly to obtain and which, otherwise, might have remained in the archives. The Second Supplement to vol. III contains a valuable digest of the Nile gauge readings as well as a complete list of the levels of the zeros of the Nile gauges, with details of how the values have been arrived at. These and the normals will be very useful for reference, though their practical value would have been increased if the maximum and minimum readings with their dates had also been included.

Vol. V, on the hydrology of the Lake Plateau and Bahr el Jebel, is in a different category. It will be read with profit by those interested in the schemes for conserving and developing these waters, it is essential to geographers, and much of it may be read with interest by the general reader. A result of measuring the Nile on the latest maps is that its length from the headwaters of the Kagera river to its mouth on the Mediterranean is 4150 miles. The Mississippi-Missouri, the longest river in the world, is about 90 miles longer, the Nile is second, and the Amazon third with 4000 miles. Plate 5 shows the profile of the Nile during flood with the slopes of its various components. The very flat slope of the White Nile suggests that at one stage of the river's history there was a lake in this region. This feature of the profile may however be explained by the course near the Sixth Cataract having been blocked by the delta of a tributary, the present slopes upstream being dependent on this interruption. Probably we have not yet enough data to show in detail the slopes associated with the individual cataracts below Khartoum. The tables and diagrams show the quantities contributed to the discharge of the Nile by its tributaries month by month for the year.

There are several most valuable maps showing the results of the air survey of the river through parts of the swamps, but it is unfortunate that the positions

of Nile gauges and reference poles are not shown on them. Jonglei is often referred to, but only the position of Old Jonglei is shown. In most profiles the down-stream is on the left, but in 84 it is on the right. Some of the plates, 65–73, are not in numerical order, but they are in accordance with the list and are all there. Some cross-sections at the discharge sites might have been added with great advantage.

The relation between sun-spot curves and the levels of Lake Victoria is found to have no support in recent statistics, and it is pointed out that if there were a relation between the curves and the rainfall it would show more directly in the rate of change of the levels.

The value of Lake Victoria as a reservoir is dismissed. On the other hand there is much discussion of the project for storing water in Lake Albert, and the points in favour of placing the regulator some distance towards Nimule are noted. The Sadd region is described at length, and the nature and variation of the losses of water are gone into. The authors tell us (p. 115) that there is sometimes a return of water from the swamps to the river. Most frequently however they record that there is a steep transverse slope near the river and that the water-level in the swamps is below that of the river. The Egyptian Irrigation Service has for many years measured the losses from an iron tank filled with papyrus. The growth of the plant under these artificial conditions can hardly be quite normal, and the authors conclude that the results are about 30 per cent. less than the truth. Probably it would be worth while making experiments with a masonry tank whose surface was covered with *pistia*, or "Nile cabbage." *Pistia* is often found completely covering the surfaces of rock pools at a distance from the Nile and can probably be relied on to thrive under such conditions. It is admitted that the soil when flooded absorbs a notable quantity of water which is eventually either evaporated or transpired when the water-level falls away from it. Apart from this it seems to be assumed that the channel is practically impermeable. This is supported by the fact that pits near the river, and reaching well below its level, remain dry for a considerable period, but in places the clay is underlain by permeable sand from which wells may draw water. There is certainly a small but steady loss of water into the ground, the amount of which might be sought experimentally by measuring the losses from a tank with a soil floor and comparing them with those from an otherwise similar tank with a sealed floor.

Attention does not seem to be sufficiently drawn to some chemical features. The salt springs near Kibero on Lake Albert may help to account for some of its content of dissolved solids. Any one who has flown across the swamps near Shambe in the Sadd region must have been struck by the turbid appearance of the water in the main channel in contrast to that in the lagoons. Long ago Dr. W. Beam pointed out that the distinct turbidity of the White Nile water was no doubt related to the deflocculating effect of its slightly alkaline water in contrast with that of the Blue Nile.

It is good to find matters treated statistically, but the authors are well aware of the weakness of some of their data and consequently of the results issuing from the mathematical mill. No one need be deterred by the equations, for there is much very interesting material in addition. The remarkable conclusion is reached (pp. 229–30) that on the Bahr el Jebel disturbances at high levels travel more slowly than at low levels. The rate of travel of disturbances on the Blue Nile has long been studied, and they travel much faster in flood than at low stage, as is usually the case with rivers. The authors remark that the velocity of changes in water-level is not necessarily that of the water. Perhaps the change in water-level may be pictured as a wave only affecting intermittently

the water through which it travels. There is evidently food in this problem for much consideration and discussion, and it is hoped that Dr. Hurst will return to it.

Backwater effects due to the Sobat may account for a difference of 50 centimetres in levels at Lake No, but they seem soon to die out when traced into the swamps. Enough has been said to show the general character of the work, and it only remains to record appreciation of the far-sighted action of the Ministers of Egyptian Public Works in supporting research which is vital to the schemes for using the Nile waters, and for making the information available to all interested in the Nile or in similar problems elsewhere. G. W. G.

NORTH AMERICA

CANADIAN MOSAIC: the making of a northern nation. By JOHN MURRAY GIBBON. *London: J. M. Dent and Sons*, 1939. 9½×6 *inches;* xiv+456 *pages; illustrations and map.* 21*s*

This is a survey of the numerous racial groups of Canada, and its object is "to trace the history of each group from its original home in Europe." The book is an elaboration of talks incidental to a series of musical radio programmes, delivered in Canada in 1938, and is admittedly popular in character. An account is given of the contribution made to the history and civilization of Canada by twenty-five European peoples, a chapter being devoted to each people.

The author has drawn on an immense number of miscellaneous sources for his material, and his book will have plenty of interest for the general reader. A most attractive feature is the collection of coloured plates, lithographic reproductions of studies of European types by several artists. In addition there are about a hundred photographs, many of them of considerable interest for the early history of Canada. The book is, as its title implies, a mosaic, and, while it is difficult to read it right through, many readers will dip into it at random with enjoyment. E. W. G.

THE SOILS OF MANITOBA. By J. H. ELLIS. *Winnipeg: Manitoba Economic Survey Board*, 1938. 11×8½ *inches;* 112 *pages; illustrations and maps*

Professor Ellis, of the Soils Department, University of Manitoba, has written a very able and clear volume on the soils of Manitoba. The work is based on the reconnaissance survey and laboratory analysis of soil samples, and the text is illustrated with more than fifty photographs and diagrams. A pocket at the end of the volume contains four sheets of the survey on a scale of 3 miles to 1 inch, covering the majority of the Province between the south end of Lake Manitoba and the international boundary, on which the Survey has naturally concentrated its work. The sheets show generalized types with brief descriptions of land classification and use, soils, and soil problems. The result is a very commendable map which might have been made clearer if it had been possible to employ colour.

After an introductory chapter the author deals systematically with the various factors which have affected Manitoba soils, before giving an account of the regional and local soil types. The author might have supplemented his account of the soils by publishing in detail the results of laboratory analysis, if only for the sake of enabling comparisons to be effected with other areas. A most interesting chapter is devoted to major soil problems. It is a sobering reflection on man's misuse of the land that perhaps the most important part of the book should have to be devoted to remedies for the deterioration already wrought or threatened in the soils of the Province. The author makes many useful recom-

mendations for the Government, interested in the whole Province, and the farmer, interested in each field. Some of his suggestions are likely to result in considerable changes in the appearance of the Manitoba landscape, especially the planting of wind-breaks of *caragana*. He urges too that submarginal land should be retired to pasture or forest and that the Government should ensure that in a spell of good years such land should not again be ploughed.

While the book contains much that is of technical and practical value, it is nevertheless written in a style which is attractive and interesting to the general reader. E. C. W.

CENTRAL AND SOUTH AMERICA

A FORGOTTEN RIVER: a book of Peruvian travel and botanical notes. By CHRISTOPHER SANDEMAN. *London: Oxford University Press*, 1939. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xii+300 *pages; illustrations and maps.* 12*s* 6*d*

The forgotten river is the Huallaga, a little-traversed southern tributary of the Marañon or Amazon lying wholly within the borders of Peru. Mr. Sandeman and his companion Michael O'Halloran started from Tingo Maria, a small settlement at the head of the navigation, and floated down the river to Yurimaguas, a distance of over 300 miles in a straight line and doubtless much more along the line of the river. The source of the river near the great mining centre of Cerro de Pasco is at about 14,000 feet above sea-level, while Yurimaguas is at only 580 feet; many rapids have to be negotiated, and this constitutes the chief danger of the journey. It was made with rafts constructed of the light and porous wood of the balsa tree (*Ochroma*), with a platform of bamboo built up in the middle of the raft on which the baggage is stowed and the passengers sit. So soft and porous is the balsa that new rafts had to be constructed twice during the downward trip. From Yurimaguas the travellers returned by an ancient trade route across the High Andes *via* Moyobamba and Cajamarca to the Pacific coast with a mule train. From Cajamarca back to Lima they travelled by a motor car, and this was not the least adventurous part of the journey.

Mr. Sandeman is a gardener and a botanist, and the main object of his journey was to collect examples of the flowering trees, shrubs, and plants which he came across; his narrative, in the form of a diary, is full of accounts of the wonderful botanical treasures encountered in the great rain forest which is almost continuous along the course of the Huallaga. His plants have been submitted to the authorities at Kew and several novelties have been found among them.

With the inhabitants, both Spanish and Indian, Mr. Sandeman seems to have got along famously, chiefly through his knowledge of Spanish; and though the standard of living was remarkably low, he and his friends managed to adapt themselves to the dirt and the insect pests from which they constantly suffered. The diary is full of humour and gentle irony and is written in a literary style far above that of the usual travel-book. It is illustrated with photographs reproduced from the author's snapshots, adequate but not of the highest quality, and there are two sketch-maps by which the route of the journey can be very easily followed. W. L. S.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

A TEXTBOOK OF GEOLOGY. Part I. Physical geology. By CHESTER R. LONGWELL, ADOLPH KNOPF, and RICHARD F. FLINT. Second edition. *New York: John Wiley and Sons—London: Chapman and Hall*, 1939 (*first published in* 1932). 9×6 *inches;* xii+544 *pages; illustrations and maps.* 18*s* 6*d*

The three authors are all professors of geology in Yale University, where there has long been a flourishing school in this subject and many standard textbooks

have been produced. Benjamin Silliman gave his 'Outline' in 1829. J. D. Dana's 'Manual of geology' passed through four editions from 1863 to 1895, and his 'System of mineralogy' through six editions, 1837–92. Later, in 1915, appeared 'A textbook of geology,' part I on physical geology by the late Professor L. V. Pirsson, and part II on historical geology by Charles Schuchert (3rd edition, 1933, by C. Schuchert and C. O. Dunbar). A third edition of Pirsson's 'Physical geology' was revised in 1929 by these authors, and in 1932 a further revision, still with the same title, was issued under their own names. A notice of this appeared in this journal (*Geogr. J.* 81 (1933) 463).

The present volume has been still further revised and shows an increase of thirty pages. This is accounted for by the addition of two new chapters: "Mass-wasting at the earth's surface" and "Sculpture of the land by streams and mass-wasting," which will be found to be of special interest to geographers. The former deals with soil-creep (solifluction) and land-slides, and their connection with farming and engineering problems. The excellent illustrations, 341 in number, add much to the attractiveness of the volume; nearly all of them are from American examples. A special feature is the block-diagrams illustrating the relation between the underlying geological strata and the surface geographical features. This is an excellent and readable textbook. The same authors have also produced a shorter version under the title 'Outlines of physical geology' (*Geogr. J.* 84 (1934) 454). L. J. S.

BIO-ECOLOGY. By FREDERIC E. CLEMENTS and VICTOR E. SHELFORD. *New York: John Wiley and Sons—London: Chapman and Hall*, 1939. 9½ × 6 *inches;* vi + 426 *pages; illustrations and maps.* 22*s* 6*d*

ANIMAL ECOLOGY. By A. S. PEARSE. Second edition. *New York and London: McGraw-Hill Book Co.*, 1939. 9 × 6 *inches;* xii + 642 *pages; illustrations and maps.* 30*s*

"Ecology is the branch of biological science that deals with relations of organisms and environments" (Pearse). This definition indicates the intimate relation of ecology to geography, which is largely a science dealing with the immense variety of environments found over the earth's surface. Since ecology aims at a causal analysis of the distribution and dynamics of living organisms, its importance for geographers generally, and for biogeographers in particular, is obvious.

For various reasons, the ecological approach to living organisms began in botany much earlier than in zoology, and both plant and animal ecologists worked independently of each other and not always along similar lines. Since however plants are an essential part of animal environment, while, on the other hand, vegetation is very often influenced by animals, it was necessary to unite the two artificially divided branches of ecological science. The specialization ruling in biological sciences made this a difficult task, and it is not surprising that no one had ventured to undertake it until the two leading American ecologists, F. E. Clements (botanist) and V. E. Shelford (zoologist), combined to produce the first book on "bio-ecology." The title is scarcely a happy one, since ecology is a biological science and the prefix is superfluous.

The outstanding feature of their book is that both authors belong to the American ecological school (largely developed by them) which stresses the study not of individual organism in its relation to environment, but of whole communities found within a definite natural habitat which are supposed to form a "biome," or a complex of plants and animals more or less closely interconnected so as to form a social organism. The concept of the biome is, as the authors admit (p. 20), "a logical outcome of the treatment of the plant com-

munity as a complex organism, or super-organism, with characteristic development and structure." This conception of plant communities is not new and rests on a very solid basis of observed facts and experiments which show how a given community develops, changes, and gives way to another (ecological succession). It was very tempting therefore to expand this principle and to regard all the animals within a plant community as parts of a single super-organism, and the authors boldly decided to adopt this view as a postulate. In support of it, views of some other writers are quoted, but no mention is made of the opposite views expressed by many animal ecologists. This dogmatic approach to the subject is characteristic of the book. Indeed it appears even intentional, since on p. 249 it is stated: "In preparing this book two courses were open to the authors: either to present a description of examples of natural phenomena with which the book is concerned as a basis for general discussion to follow or to reverse the order. The reverse order was chosen, but not without misgivings."

The misgivings were fully justified, since a reader is confronted in the first seven chapters with a lengthy exposition of principles unsupported by proofs, and only the last three chapters are devoted to examples of biomes, namely the North American grassland, fresh-water communities, and marine communities. Such restriction of illustrations of the principles is most disappointing, particularly for a geographer who might have hoped to find in the book a wider treatment of the many types of natural communities.

Several of the introductory chapters contain information of immediate value to geographers. Chapter III is particularly interesting, as it contains many examples of the influence of plants and animals on the habitat (formation of soil, changes in its composition and structure, erosion phenomena, etc.). Chapter IV contains a summary of data on the influence of animals on plant communities, *e.g.* effects of grazing and browsing, of defoliation, etc.

A serious drawback to the book is the liberal use of technical terms, many being introduced for the first time. To give only one example, the term "ece" is suggested for "habitat" and commended for its "brevity, euphony, and significance"; the necessity of this term is well illustrated by the fact that it occurs only two or three times throughout the book. Most of the other terms are used from the first page onwards, while their definitions will be found only in the middle of the book. The style generally is anything but easy, as can be judged from a typical quotation: "Dominance is the condition of control of community character and composition that results from the successful outcome of reaction, coaction, and competition, the opposite effect being seen in subordinance" (p. 235). A bibliography at the end of the book appears to be fairly complete as far as American literature is concerned, but many important European works are missing. Some references are inaccurate, *e.g.* it will be impossible to find a paper by Paczoski, whose name is spelt Jaczoski, even in the bibliography, where it appears under the letter J.

A book on general ecology, such as would be indispensable both to biologists and to geographers, still remains to be written, for 'Bio-ecology' is too biased in favour of a single theory and too technical to be of direct use to non-specialists. Professor Pearse's book (now in its second edition) deals only with animal ecology and represents a most conscientious summary of carefully classified facts. This treatment makes it a mine of information, a great deal of which should be of value to students of geography. The following sections might be specially mentioned in this connection: ecological factors (Chapter IV); zoogeography (p. 155); succession (p. 163); ocean (Chapter VIII); types of fresh waters (Chapter IX); terrestrial habitats (Chapter X); economic ecology (Chapter XIV). The bibliography of sixty-five pages can be safely recommended to any

one in need of ecological facts. A more critical approach to the selection and arrangement of the facts would be an improvement which might be considered in future editions. B. P. U.

ECONOMIC AND HISTORICAL GEOGRAPHY

THE LIFE AND ACHIEVEMENTS OF CAPTAIN JAMES COOK: explorer, navigator, surveyor, and physician. By Surgeon Rear-Admiral JOHN REID MUIR. *London and Glasgow: Blackie and Son, Ltd.*, 1939. 9×5½ *inches;* 310 *pages; illustrations, portraits, and maps.* 19*s* 6*d*

The life and achievements of Captain Cook have so often been recounted that, in the absence of fresh documentary evidence, there is little left for new biographers but to emphasize a particular aspect of his work. Admiral Muir has concentrated largely upon Cook's care for the health of his crews, and sets out very clearly the state of contemporary knowledge and the measures advocated for combating disease, particularly scurvy. He shows that credit is due to Cook, not for the evolution of original theories, but for putting into practice the best ideas of the times. He concludes that Cook's success was due to his insistence upon fresh food and water, adequate clothing, and personal hygiene, rather than to the many anti-scorbutics he favoured, much of their value being destroyed by the methods of preparation. It was a stroke of ill-fortune that the dysentery which killed many of the crew in the *Endeavour* at Batavia was probably due to Cook's faith in fresh fruit as a preventative of scurvy.

The remainder of the book is largely a summary of the printed accounts of the three voyages, supplemented by what little is known of Cook's personal life. This is adequately done, with due reference to recent published research, but hardly justifies the publication of another biography. The author, like so many of his predecessors, is an unqualified admirer of his subject; it may perhaps be pointed out that the word "genius" as used of Cook by his contemporaries had not quite the modern meaning. G. R. C.

GENERAL

THE NATIONS TO-DAY: a physical, industrial, and commercial geography. By LEONARD O. PACKARD, CHARLES P. SINNOTT, and BRUCE OVERTON. *New York and London: The Macmillan Co.*, 1939. 9½×6 *inches;* viii+728 *pages; illustrations and maps.* 10*s*

Without more knowledge of the type of school and the methods of teaching envisaged by the authors, it is difficult to assess the value of this book. It begins with a summary, "The basis of man's life and work," which appears to presuppose considerable knowledge of the subject-matter of geography. This is necessarily very much condensed, but that hardly excuses the inaccuracies which occur. The largest section of the book is devoted to an account, mainly commercial, of the U.S.A. This makes interesting reading matter, and the description of some of the processes of industry, *e.g.* plastics, is fascinating. The last section covers the rest of the world in lessening detail. Again condensation may excuse much, but evidences of haste and inaccuracy would make one very uneasy in using the book in schools. It seems unfortunate that maps of such poor quality should be included in a geographical work. This applies particularly to Plates 1–8. One regrets too that the term "research" should be used of very elementary school exercises, *e.g.* p. 110 (4), p. 310 (5). The book is profusely illustrated, but many of the illustrations have little or no geographical value. It is well printed on good paper, but too heavy to be handled with comfort in the class-room. G. M.

THE MONTHLY RECORD

A PICTORIAL SURVEY OF ENGLAND AND WALES

A scheme for a pictorial survey of England and Wales was originally suggested some years ago at a conference of the Heads of several University Geographical Departments. After many vicissitudes, the proposal, which had in mind a survey for the use of students and teachers in Secondary and Public schools, has been taken up, and the first section, on the Oxford region, has now been published (London: George Philip and Son, Ltd., price 2*s*). The aim is to show the relationship of surface form to geological structure and the effect on settlement, communication, and development; this has been achieved by a series of plates, printed on one side only, each accompanied by a sketch-map and a brief text. In some cases explanatory drawings of the photographs are included. The compact summary of the Oxford region by C. R. Gullick suggests that the series will form a useful addition to the reading list of all geographical students up to and including first year university students, although for serious study the survey would seem to be more appropriate for School and Higher School Certificate work. In the latter case considerable oral teaching would be necessary and attention would of course be concentrated in the first instance on the home region. Being printed on one side only the plates are readily adaptable for wall illustrations and use in the epidiascope. Probably in many cases loose-leaved copies would be of great help, and this may be worth considering in future publications, whilst for junior work a greater proportion of interpretative drawings would be an advantage.

Those concerned in the present production are to be congratulated. Regions will not in all cases lend themselves to the same method of treatment, and account must also be taken of the author's interpretation of the spirit of the area; the rest of the series (Section II, on the Cambridge area, has been prepared) will consequently be awaited with considerable interest. W. G. V. B.

WAR MAPS OF GERMANY AND ADJACENT COUNTRIES AND OF THE WESTERN FRONT

These two publications will prove extremely useful to all who attempt to follow the course of present events with a map. The map of Germany and Adjacent Countries (1 : 2,500,000, price 2*s* 6*d*) is layered with nine tints, in the style made familiar by the firm of Bartholomew, and has international boundaries in red and administrative boundaries, equivalent to the county, in a fine dotted line. Rivers and railways are shown by a black line, but there is never any real confusion between the two. The map of the Western Front (1/M, price 5*s*) is more closely layered and the selection of colour boundaries has been chosen to reveal the escarpments of the Paris basin as well as the more difficult terrain east of the Siegfried Line. The red plate has been used for both the international boundaries and the two defence zones running north from Basle. The roads are shown in brown, with the distances between towns in kilometres on the Continent and miles in England. The *Autobahnen* are differentiated by a cross hatch on the road lines, and the strength of this symbol might be increased with advantage. This map, taking one from Tours to Salzburg and Hull to Berlin, is most useful for studying the course of the war and will also be of value for the post-war traveller in these regions. Both maps are linen mounted.

A. C. O.

MARCO POLO IN PERSIA

Our notice in the *Journal* for July 1939 of Sig. Franchi's discussion of Polo's "Solitary" or "Dry" tree in Persia has brought us a communication from an

American student, Mr. F. Howland, on a closely associated problem, that of the site of the place Temocam or Tunocain (variants adopted by one or other of the commentators). This Sig. Franchi identified with Damghan, near the south-east corner of the Caspian, as suggested by the first spelling, while most students, including Yule, placed it in Khurasan, considering the second form to be a combination of the names of the two districts Tun and Kain. Mr. Howland thinks with some reason that this latter identification is unsatisfactory, as the places are separated by 100 miles of nearly desert country and would not naturally be coupled together. On the other hand Damghan does not fit in well with Polo's itinerary, the time taken from thence to Balkh being far too short: it would be shorter than we should expect even if the Tun site were accepted. Mr. Howland puts forward another suggestion which seems worthy of consideration, that the place was either Herat or some town in its vicinity, and that the name was really the true name of Chinghiz Khan (the latter being an assumed title), namely Timochain or Temuchin, and that it was temporarily an official designation given to the place in his honour. The fact that Herat lies on the most probable route of the traveller, but is not definitely mentioned in his narrative, lends some support for this view, though the absence of mention might be due merely to the more or less ruined condition of Herat at the time. Mr. Howland bases his argument in part on the absence of Herat from the earliest (sixteenth century) European maps of central Asia, thinking apparently that the name long remained in disuse. But the city had recovered its position much before the sixteenth century, as shown by its description in the fourteenth as a large city, one of the chief in Khurasan, by Ibn Batuta, who visited it himself and spoke of it by its usual name. And that name does appear on some European maps of the sixteenth century, being plainly shown, for example, on its river, in Mercator's world-map of 1569—here in the form "Heri" adopted by Muhammadan writers. (It had already appeared as "Eri," in the Catalan map of 1375.) It may be noted that Mercator shows "Timochan" also, no doubt on Polo's authority, but misplaced a good way to the south-east. Mr. Howland allows that his theory does not well explain the digression on the Old Man of the Mountain, and he does not enter into the question of the "Dry Tree." E. H.

THE BRITISH CENTRAL AFRICAN TERRITORIES

The Report of the Rhodesia–Nyasaland Royal Commission, set up to inquire into the desirability and practicability of closer union between these territories, contains a considerable amount of useful information on their present administrations, services, native policies, land tenures, finances, and economic development. The Commission rejected federation as an immediate policy, but considered that amalgamation should be the ultimate aim, and suggested several spheres in which immediate cooperation should be initiated. The obstacles to federation were considered to be the status of Southern Rhodesia as a colony enjoying a large degree of self-government, in contrast to the Protectorates of Northern Rhodesia and Nyasaland, administered by the Colonial Office; the differences in native policy, natives in Southern Rhodesia having only recently been associated with the administration of their affairs, while in the two Protectorates indirect rule is practised; the present inequality in economic stability and development between the three territories; and the necessity for preparing the European settlers for the wider responsibilities that federation would entail.

The European population of Southern Rhodesia in 1936 was 55,408, having increased from 49,910 in 1931, compared with a total white population in the two Protectorates of 12,426, a figure which shows a decline of 3395 on the returns for 1931. As regards the native populations, although that of each

territory is approximately 1·5 millions, the average density per square mile in Nyasaland is over five times that of Southern Rhodesia. The bearing of these considerations on federation are plain, and the problem is not simplified by the fact that Southern Rhodesia depends to some extent on labour migration from Nyasaland. Although gold has a predominant share in the export trade of Southern Rhodesia, amounting to 53 per cent. of the total exports, and other minerals and coal amounted to 20 per cent., agricultural exports were by no means negligible, tobacco, meat, and maize amounting to 17 per cent. On the other hand, in Northern Rhodesia the demand for agricultural products is practically limited to the mining zone, and little is exported. Thus the exports are dominated by copper, amounting in 1937 to 89 per cent. of the total, a further 5 per cent. being represented by zinc and cobalt alloy. It is interesting to note the increasing importance of tea among Nyasaland exports, the figure rising from 12 per cent. in 1933 to 37 per cent. in 1937, the percentage share of tobacco having fallen over the same period from 76 to 48. Despite however the characteristics of their economy, trade between Northern and Southern Rhodesia has been increasing in the last five years. In 1937 Northern Rhodesia obtained 15·6 per cent. of her imports from Southern Rhodesia, amounting to £627,000, plus £903,000 of re-exports. The Report is accompanied by a number of useful maps in colour on the scale of approximately 1/2·6M, showing the distribution of population, agriculture, mines, industries, and tribes.

AIR PHOTOGRAPHS OF THE APPALACHIANS

The value of air photographs in elucidating the relations of topography, structure, and geology is once again demonstrated by a series of forty-two photographs taken on a regular passenger flight from Washington to Cincinnati in May 1938 and published by Mr. John Rich in the *Geographical Review* for October. The photographs were taken with a Leica camera through the plane window in the late afternoon, in directions running from north-west through north to north-east. The topographical features are therefore emphasized by strong shadows which, though producing a slightly exaggerated effect, reveal relationships that might otherwise have been overlooked. Each photograph is accompanied by a map identification, calculated from speed and time of exposure, and a brief commentary on the main features revealed, checked by subsequent observation on the ground.

The series form a cross-section, largely continuous, of an area particularly rich in examples of anticlinal and synclinal folding in various stages of erosion, running from the eastern piedmont plateau across the Blue Ridge, the ridge and valley province, the Alleghany front, and the Appalachian plateau to the plains of Illinois. The photographs bring out strongly the formation of ridges and interior valleys in the succession of north–south folds, contrasting the residual mountains of the Blue Ridge with, for example, the synclinal Massanutten mountain; the formation of Lost Creek valley along a strike; and the regularity of the folding west of the Shenandoah. Other interesting features here are the unusual incised meanders of the north branch of the Shenandoah, and the scalloped ridge of the New Creek anticline. The scattered and isolated character of settlement, and its relation to structure and geology, is also well brought out. The second main area, the Appalachian plateau, with its well-marked eastern front, approaching 2000 feet in height, affords a further contrast; its flat eastern section, bare, rocky, and windswept, with settlement confined to a few mining centres, even more desolate than the folded Appalachians. Farther west, the fertile Canaan valley, along the centre of an eroded anticline, again illustrates the relation of settlement to geology. Other interesting photographs are those

of the great abandoned meander terraces of the Little Kanawaha river, and of the two discordant drainage systems in the area east of the Ohio, to the south-west of Parkersburg. In addition to conveying a vivid impression of the character of this region, the photographs will serve as a useful supplement to textbook explanations of structural and mountain-forming processes. Mr. Rich deserves credit for having made so profitable use of his opportunity.

THE FLOATING GARDENS OF XOCHIMILCO

The floating gardens of Xochimilco are described by Elisabeth Schilling in Bd. 9, Hf. 3 of the *Schriften* of the Geographical Institute of Kiel University. When the Spaniards entered the central basin of Mexico they were surprised by the sight of large orderly arranged settlements in the midst of great fields of blossoms intersected by canals along which a brisk traffic was in progress. This landscape, fashioned by the Indians in the shallow lake of Xochimilco, has persisted until the present, though its future is now threatened. Between the canals the Indians had built small artificial islands known as *chinampas*, upon which, without the use of manure or elaborate agricultural implements, flowers and vegetables were grown. The "islands" were formed of rafts of decaying vegetation, reeds, and roots, which were anchored by thrusting quick-growing slips of *Salix Bonplandiana* through them. The term "floating garden" is therefore incorrect, and the reports of earlier travellers were based on a misconception. The Xochimilco Indians appear to have settled in this area towards the end of the thirteenth century, and the evidence of the village names shows that they were founded in connection with this form of cultivation. The effect of the Spanish conquest was to destroy the ascendency of Tenochtitlan, the Indian city upon which the economic prosperity of the Xochimilco region depended, large numbers of Indians were removed as soldiers, and Spanish attempts at exploitation failed through applying an unsuitable technique. More recently the rise of the city of Mexico has provided a new market for the produce, but the measures taken to supply the capital with water have irretrievably lowered the ground water-level, and with the canals will disappear this unique form of Indian cultivation.

GEOGRAPHICAL ACTIVITY IN BRAZIL

In recent years Brazilian geographers have been very active in securing general recognition of their science and in organizing the cooperation of geographical institutes and individuals to spread an understanding of the geographical problems of Brazil among the public. In 1933 Professor E. de Martonne, as Secretary-General of the International Geographical Union, invited Brazilian geographers to form a National Council for Geography and to adhere to the Union. Certain difficulties prevented the immediate acceptance of this invitation, but those interested in the subject continued their work. Through the activities of Dr. M. A. Teixeira de Freitas a National Institute of Statistics was founded, with the support of the Federal and State services. Finally, on the initiative of Dr. J. C. de Macedo Soares, Foreign Minister and President of the Institute, a National Council for Geography was established, and incorporated in the Institute in March 1937. The Council will work in cooperation with the Ministry of Education and Health and the military services, and is entitled to receive a copy of every map and publication on the geography of Brazil. The Institute on behalf of the Council is publishing the *Revista Brasileira de Geografia*, of which two numbers have appeared this year. These contain, amongst other material, two long instalments of a monograph on the human geography of Brazil by Professor P. Deffontaines, a geographical survey by Sr. Fróis Abreu of the Recôncavo district of Baía, where good quality oil has

been struck, and an account of the measures taken to secure uniform maps of all municipalities. It is also announced that the Council has been charged by the government of the Union with the production of a map of Brazil on the scale of 1/M, using as a basis the map on this scale, adhering to the pattern of the International Million Map, published by the Clube de Engenharia to mark the centenary of Brazilian independence.

The *Revista* maintains throughout a high standard of interest, is well illustrated, and is excellently produced.

CONDITION OF THE PROVINCE OF AYSÉN

The present condition of the province of Aysén and its possibilities for the future are discussed by Captain Pablo Ihl in the *Memorial Técnico*, No. 27, 1939, of the Chilean Army. The writer was a member of a scientific and military expedition which visited this portion of Chilean Patagonia in the first quarter of this year. The party, composed of surveyors, scientists, and mountaineers, travelled from the chief town of Puerto Aysén up the road along the valley of the Rio Simpson to the new and flourishing settlement at Baquedano, and thence by tracks across the divide to Puerto Ibáney on Lake Buenos Aires. Skirting the north-west shores of the lake, they proceeded up the valley of the Rio Leones, a river coming down from the main glaciated cordillera, with the intention of crossing to the west coast. However, after penetrating some distance into the mountains, and discovering four large lakes, the party was obliged by bad weather to return. A good route between Lake Buenos Aires and the Pacific is said to lie to the north, *via* the valley of the Rio Exploradores.

The greater part of the article consists of a brief systematic description of the area. Physiographically, it is formed by the coastal cordillera of the west, with a very heavy rainfall; and a zone of transition which gives place on the eastern boundary to the level meseta of Argentine Patagonia. This area is drier than the western, and enjoys on the whole a climate similar to that of the Spanish highlands, having a rainfall about one-third that of the coastal region. The annual rainfall at Puerto Aysén is 260 centimetres, the wettest months being July and December, and the driest October and November. It is this interior zone, well watered and possessing natural resources, that offers possibilities for the future. At present a certain amount of sheep and cattle are raised; the census of 1938 gave 600,000 sheep and 25,000 cattle. The obstacle to further development is the lack of communications, complicated in the east by the boundary with Argentina. The writer recommends, in place of a through longitudinal route with perhaps a costly railway line, the improvement of the transverse routes in conjunction with increased shipping services along the west coast. This development would also offer to western Argentina a short and cheap outlet for its products. The Government have already taken steps to improve the local shipping services between Puerto Montt, the southern terminus of the railway, and Puerto Aysén, and the road system is being considerably extended.

CORAL RESEARCH IN MORETON BAY

Miss Dorothy Hill, Honorary Research Secretary of the Great Barrier Reef Committee, has sent us a short note on a two-day excursion of students to Moreton Bay. The note itself summarizes their activities, but is more important in making it clear that there is active interest in Brisbane in the scientific exploration of the bay. It is unnecessary here to quote in detail the species of coral found; suffice it to say nine were seen and seven collected. The students examined the growing coral carefully in relation to depth of water and the nature of the bottom. Anemones, sea-urchins, and other marine creatures were

also collected. Observations were also made on ripple marks and related features. The note, as such, is very brief, but it is clear that Mr. Riek (who wrote it) has made an excellent start and deserves all success. We look forward to further and more comprehensive accounts of what promises to be a fruitful area of research. J. A. S

THE ORIGIN OF COOK STRAIT

Several suggestions have been put forward to explain the existence of Cook Strait, the dislocation in a distance of 15 miles of the main physiographic features, and an apparently abrupt geological break between the North and South Islands of New Zealand. The observed distributions do not support the hypotheses of a general subsidence or of vertical movement. In a paper published in the *Transactions* of the Royal Society of New Zealand, Part 4, 1939, Dr. L. C. King, after examining earlier suggestions, advances an hypothesis based upon work in this area. His theory is founded on lateral displacement, the central portion of New Zealand having been subjected to intense shearing stress in the later stages of the compression which formed the New Zealand mountain ranges. According to this theory the South Island has moved westwards at a relatively greater rate than the North Island. In the region (in Palliser Bay for example) there is evidence of the former presence of forces of compression: the outline of Cook Strait has been determined by fractures, and the structure of the Marlborough Sounds area suggests that this has undergone a special history. The author believes that under the forces postulated this area swung round to the east about its southern apex, having formerly occupied the Tasman Bay area, the latter therefore being the result of a split, the southern portion of which was filled in with Moutere gravels. A continuance of this movement carried the Marlborough block farther to the west, resulting in a further rifting which now forms Cook Strait. The writer holds that assuming this movement it is possible to trace a close stratigraphical and structural correlation between the North and South Islands. The western type of structure of the South Island is present north of Wellington, and the Kaikoura mountains have their counterpart in the Haurangi. Evidence that this movement was relatively recent is supplied by the botanical distributions, and to a less certain extent by the fauna.

THE *POLAR RECORD*

In No. 16 of the *Polar Record* the editor said that he proposed to publish special authoritative articles on polar subjects and that as these were matters of experience and opinion, he hoped they would give rise to correspondence. The *Record* for July last is an excellent product of this policy.

Besides the usual detailed account of polar activities, present and projected, there are articles of value to the polar specialist and to the plain geographer: a clear statement of the Norwegian claims in the Antarctic; notes on the fur industry and mining in the Canadian Arctic, with reference to the cycles of fur-bearing animals and some recent discoveries of gold in the Yellow Knife river; and an account of the Polar Eskimo of North-West Greenland by J. W. Wright.

The article and correspondence on dogs and dog-driving show how authorities may differ. "The management of sledge dogs," by Messrs. C. G. and E. G. Bird, gives a much more refreshing impression of dog-driving than do some former articles; and these authors have not only polar experience but much knowledge of dogs in England.

The article on the Polar Eskimo deals with a type of unspoilt native more like our textbook knowledge of such people than the Eskimo with whom we have become more familiar as a result of other Greenland expeditions. The term

"Greenlander" as used in the text must be taken as applying to the West Coast rather than to the true East Coast Eskimo, that is, to the natives living away from the big settlement, who have more in common with the Polar Eskimo.

A short but interesting article concerns insulation in polar huts and describes the application by the British Graham Land Expedition in the Antarctic of the theory that "if an air space of one inch is divided medially by a diaphragm of metallic foil, as for example aluminium foil, then the transference of heat across that space is as effectively hindered as if the space were filled with a slab of cork 1 inch in thickness."

The chief technical article in this number is one on "Survey in the polar regions," by J. W. Wright. The methods of survey discussed are primarily those which are suitable for the modern type of British expedition numbering between six and fifteen men, each of whom is a specialist in a different subject. The surveying programme of such expeditions, especially in the Arctic, consists in producing a well-controlled and fairly detailed map, in conditions to which standard methods are not applicable. After a brief review of methods practised by others the author describes in detail the method which he adopted in Ellesmere Land, surveying with a combined precise theodolite and miniature camera. The method seems to have been very well adapted to that type of country, and will no doubt be much used and improved by future expeditions. But there are still areas that demand more stress upon getting as good a map as one can in the field, without so much reliance upon the camera, measurement, and computation.

The Director in his Annual Report refers to the replanning of museum exhibits by members of his Committee, most of whom are voluntary helpers. There is now a first-class display of polar exhibits, not only of relics of sentimental value, but of modern gear such as a fully loaded sledge, dog-driving and hunting gear of all types, scientific instruments, food rations, and modern polar clothing. All these are well described by experts in each particular sphere, and the exhibition well deserves the study of any geographer. A. S.

STYLE AND ORNAMENT IN MAPS

At the Sixth Conference, in November 1938, of the British Records Association, Mr. Lynam gave an afternoon lecture on the style of English maps as it varied through the centuries, with special reference to the striking exhibition of examples shown at the evening reception the same day. His lecture is printed in the *Proceedings* of the Association, 1939, No. 4, and is welcome as a useful general introduction to the subject. He was naturally limited to an outline sketch, as he himself insisted. A leading motive in the paper was to show how a knowledge of the external characters of maps of different periods might help to place undated specimens. On a broadly chronological basis he dealt with such special characters as the colouring, for which a convention was already established in the quite early MS. plans of estates; the representation of towns and villages and of mountains; the method of distinguishing the sea, most frequently by a stipple in the earliest engraved maps; and the accessory ornament. Colouring is regarded as a special feature of the Elizabethan period, of the masterpieces of which the Saxton county maps (mostly by Flemish engravers) are so striking an example; even here however it was not quite an essential, for a good many uncoloured Saxton maps still exist. Due praise is given to the fine "Italic script" seen in these, though it should not be concluded from this that "Roman" was not also used. The style of lettering was heavier in subsequent maps of the Dutch School, like those made for Speed, and before the end of the seventeenth century became much more varied. The cartouche borders of the Flemish

School show a blend of the earlier Italian "strap-work" [1] with a kind of fret-work frame, and are decorated with birds, fruits, etc. The medium of engraving was almost solely copper down to the nineteenth century, and Mr. Lynam could only recall two English wood-cut maps, both of the late sixteenth century (Cuningham's earlier plan of Norwich (1559) is not mentioned, but this was not strictly a map). Hollar's maps of the seventeenth century are of special interest as being etched and not line-work. In the early nineteenth century steel was used for a limited period.

Mr. Lynam insists on the close copying by draughtsmen of the styles set by engravers, but one thinks that the indebtedness may have been mutual to some extent; and both must have used the same published guides to lettering. He gives instances of the help towards precise dating afforded by details like armorial bearings, or the varying styles of script. But there may be a risk of wrong conclusions, as in a case cited where some features of a map bearing date 1591 were seen to be correct for that period, but the script pointed to a century later, the latter date being only completely established by the evidence of the water-mark.

The writer's generalizations seem sometimes too sweeping, as when we are told that the "chevron" or "watered-silk" shading for the sea was almost confined to maps made by Flemish or Dutch engravers (it occurs, for instance, in county maps by Charles Whitwell and Christopher Schwytzer). But in so summary a treatment of a big subject this was no doubt inevitable. The lecture was illustrated by a number of slides and loses somewhat, as printed, by the lack of illustrations. E. H

MEETINGS: SESSION 1939–40

Fourth Meeting, 27 November 1939. The President in the Chair

Elections: Robert Dennis Althorp; Ernest Stuart Bates; The Reverend Enoch Davies, B.SC.; Alan Inglis Deacon; Harold Dodgson; The Reverend John Foster Haigh; J. Bruton Jackson, B.SC.; Khan Sahib Chaudhri Bashir Ahmad Khan; Harry Wilfred Lane, B.A.; Stanley Clifford Maylott; Sir Keith Arthur Murdoch; Miss Pamela Joan Oaten; The Reverend Alfred McDonald Queen; Peter Rainier; Keith M. Sargeant; Francis St. George Spendlove, F.R.S.A.; G. Wickremasinghe

Paper: The search for oil (The Asia Lecture, 1939). By Dr. G. M. Lees

Fifth Meeting, 4 December 1939. Professor K. Mason, Vice-President, in the Chair

Paper: The plans for a National Atlas. Discussion opened by Professor E. G. R. Taylor

Sixth Meeting, 11 December 1939. The President in the Chair

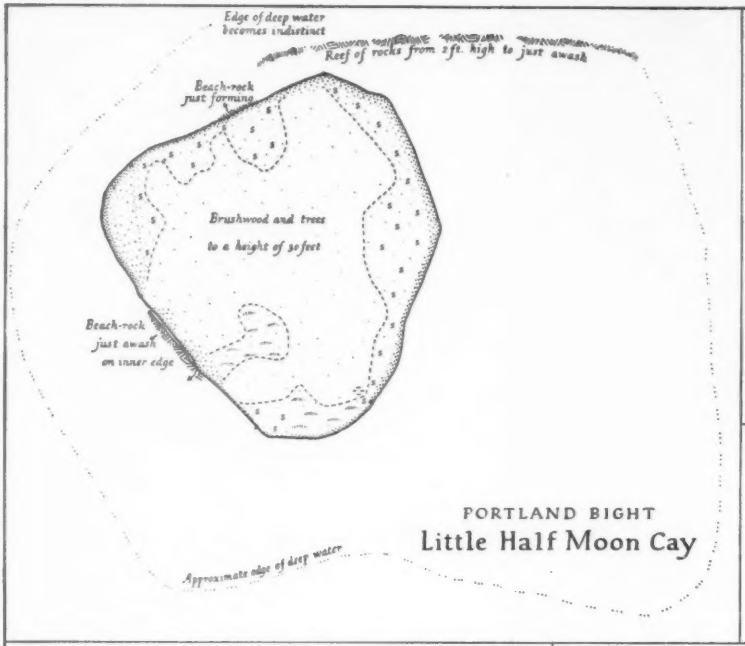
Elections: Arnold James Burton; Richard William Edwards; Horace Frederick Alfred Gates; Willard Fraser MacCulloch, B.A., B.SC.; Major T. Reynolds; The Reverend Rowland Wormell, M.A., B.D., B.SC.

Paper: Volcanoes of New Zealand. By Mr. Alan Browne

[1] Though generally accepted, this term is not altogether satisfactory, as the form so often merged into others, at least in the early maps. Mr. Lynam uses it for the cartouche in the anonymous MS. map of the British Isles of *c.* 1540, though this might rather suggest carved wood-work.

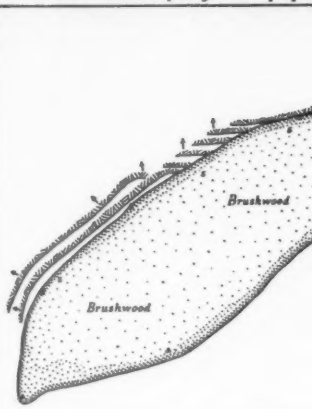
THE CORAL CAYS

to accompany the pape


Edge of deep water becomes indistinct
Reef of rocks from 2 ft. high to just awash
Beach-rock just forming
Brushwood and trees to a height of 30 feet
Beach-rock just awash on inner edge
Approximate edge of deep water

PORTLAND BIGHT

Little Half Moon Cay

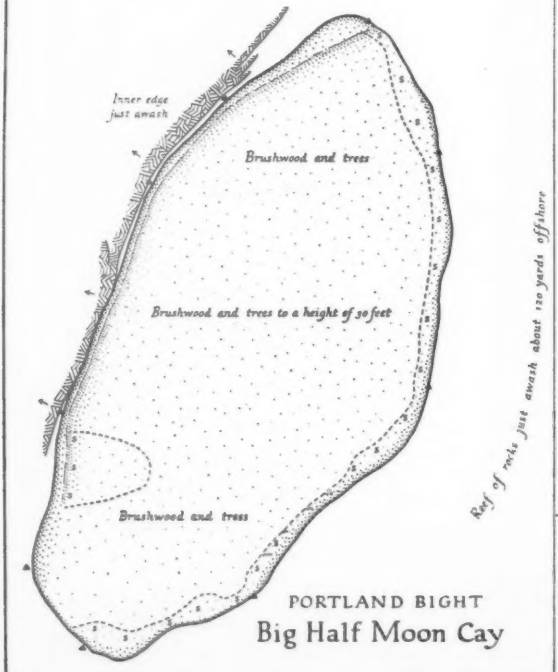


Surveyed with chain an
by J.A. Loftho

100 0 100 2

Sand & shingle Beach-rock
Sand Sesuvium Grass

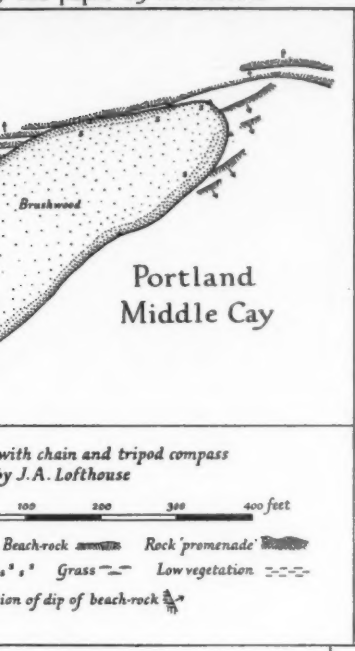
Direction of dip of be


Inner edge just awash
Brushwood and trees
Brushwood and trees to a height of 30 feet
Brushwood and trees
Reef of rocks just awash about 120 yards offshore

PORTLAND BIGHT

Big Half Moon Cay

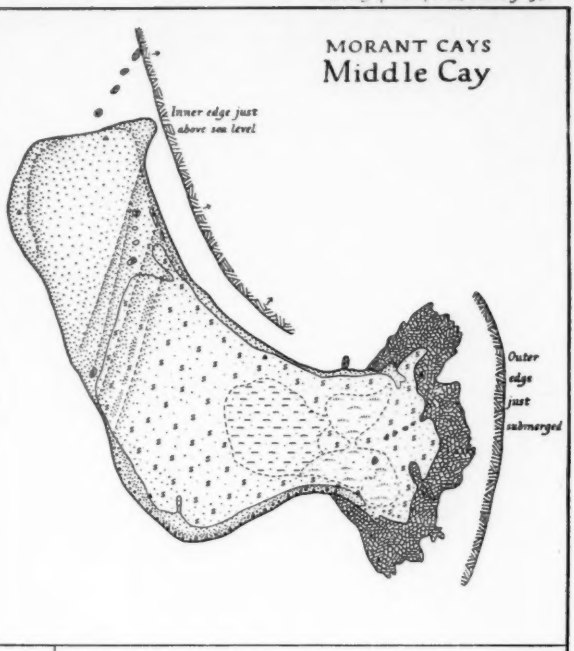
Published by the Royal Geographical So

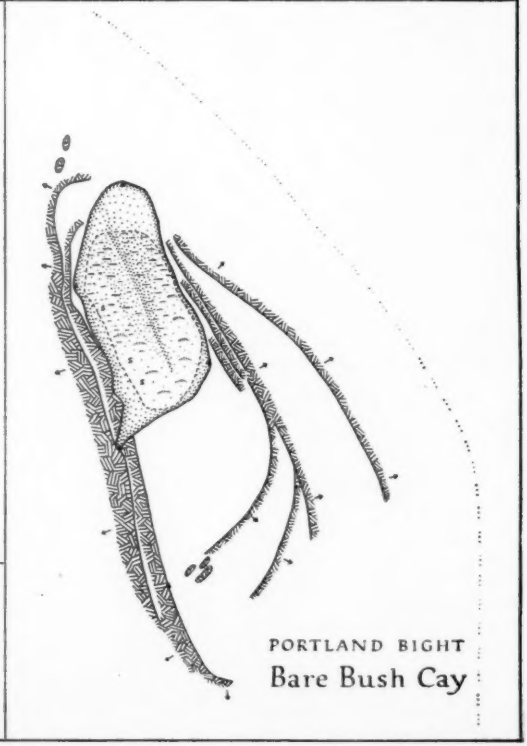


with chain and tripod compass
by J.A. Lofthouse

100 200 300 400 feet

Beach-rock Rock 'promenade'
Grass Low vegetation
ion of dip of beach-rock





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